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# UNITED STATES AIR FORCE RESEARCH LABORATORY

## BODY SIZE ACCOMMODATION IN USAF AIRCRAFT

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The voluntary informed consent of the subjects used in this research was obtained as required by Air Force Instruction 40-402.

This technical report has been reviewed and is approved for publication.

**FOR THE COMMANDER**

MARIS M. VIKMANIS
Chief, Crew System Interface Division
Air Force Research Laboratory

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The USAF is considering relaxing body size entrance requirements for Undergraduate Pilot Training (AFI 48-123) to provide equal opportunity for both genders. The research described here was undertaken from 1997 through 2000 to determine the smallest and largest people that can safely and efficiently operate each current USAF aircraft.

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To each of these people we offer our thanks.

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# ABSTRACT

The USAF is considering relaxing body size entrance requirements for Undergraduate Pilot Training (AFI 48-123) to provide equal opportunity for both genders. The research described here was undertaken from 1997 through 2000 to determine the smallest and largest people that can safely and efficiently operate each current USAF aircraft.

In the past, aircraft were measured during the procurement process, to ensure they met the specifications set by the USAF, but not to determine the absolute limits of body size accommodation. Body size limit data for each aircraft will help policy makers determine if a change to AFI 48-123 is in the best interest of the USAF by indicating:

1. If pilots of extreme size are safely accommodated in specific cockpits
2. If there are adequate career paths available for pilots of extreme body size within the current and future USAF aircraft inventory, and
3. If there are cost effective modifications that could increase accommodation levels.

This research was carried out using live subject trials N= ~25 in each aircraft, and then used multiple regression to provide the best estimate for a particular accommodation parameter. We examined seven aspects of anthropometric accommodation in each aircraft:

1. Overhead clearance.
2. Rudder pedal operation.
3. Internal and external visual field.
4. Static ejection clearances of the knee, leg, and torso with cockpit structures.
5. Operational leg clearances with the main instrument panel.
6. Operational leg clearance with the control stick motion envelope (the pilot's ability to move the stick through its full range of travel).
7. Hand reach to controls.

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# 1.0 INTRODUCTION

## 1.1 Background

The USAF is considering relaxing body size entrance requirements for Undergraduate Pilot Training (AFI 48-123) to provide equal opportunity for both genders. The following research was undertaken from 1997 through 2000 to determine the smallest and largest people that can safely and efficiently operate each current aircraft.

In the past, aircraft were measured during the procurement process, to ensure they met the specifications set by the USAF, but not to determine the absolute limits of body size accommodation. Body size limit data for each aircraft will help policy makers determine if a change to AFI 48-123 is in the best interest of the USAF by indicating:

4. If pilots of extreme size are safely accommodated in specific cockpits
5. If there are adequate career paths available for pilots of extreme body size within the current and future USAF aircraft inventory, and
6. If there are cost effective modifications that could increase accommodation levels.

With the procurement of the Joint Primary Aircraft Training System (JPATS or T-6) and its eventual introduction into the USAF and USN inventories, it will be possible to train pilots whose body sizes are considerably smaller than ever before. While the original design philosophy for JPATS was to accommodate all potential USAF pilots that meet AFI 48-123 requirements, during source selection this philosophy was modified to require accommodation of 95% of both the male and female military population, including those who do not meet the restrictions in AFI 48-123.

It is possible for pilots as small as 58 inches in Stature and 31 inches in Sitting Height to operate the T-6. However, after the T-6, student pilots must continue training in the T-1 (Tanker/Transport trainer) or the T-38A (Fighter/Bomber trainer). The T-1 and the T-38 were designed to accommodate a specific percentage (98% and 90%, respectively) of a population

with a Stature range of 64 to 76 inches, and a Sitting Height range of 34 to 39 inches. (Recently, AETC extended the large size limit to 77 inches and 40 inches, respectively.)

This is also true for the vast majority of USAF inventory aircraft, especially those designed in the 1950s and 1960s. Nearly all of these aircraft were designed to accommodate the body sizes of an all-male pilot corps. Data gathered on fleet aircraft show the smallest JPATS-eligible pilots (especially those with less than a five foot stature) will not be able to fly them safely.

While the T-6 primarily increases accommodation for smaller pilots, it also accommodates somewhat larger pilots. Maximum Leg Lengths specified in the T-6 requirements documents were several inches larger than the lengths for which inventory aircraft were designed. These larger, longer-legged pilots may suffer ejection injuries if they attempt to eject from follow-on aircraft with inadequate clearance space.

## 1.2 Cockpit Accommodation

There are a number of areas of concern for accommodation of pilots. The primary ones are listed below.

For Large Pilots:

1. When overhead clearance to the canopy is inadequate (as in the rear cockpit of the T-38A), the pilot has a difficult time assuming the correct posture for ejection, mobility to "check six" is reduced, and, during inverted flight, the head will be pushed into the canopy.

2. Inadequate escape clearances for the legs and elbows can result in pilot contact with aircraft structures during ejection. This can cause serious injury.

3. Many large pilots have minimal operational clearance for moving the controls. A typical control movement problem is body interference with the control stick range of motion, observed in the T-3. When the stick was pulled full aft and rolled left and right, its range was limited by thigh contact.

4. Shin clearance for rudder pedal operation can be severely restricted. In the F-16, for example, we have seen leg lengths so long that the pilots have difficulty operating the rudder pedals because their shins are pressed into the bottom edge of the instrument panel.

For Small Pilots:

1. For small pilots, the external visual field can be so restricted that they cannot see the runway during a no-flap landing, or have difficulty seeing their wingman during a formation rejoin. External vision is a common problem for small pilots in the T-1 and T-38.

2. Obvious problems can occur when the pilot is unable to achieve full rudder throw and operate the brakes effectively.

3. Many small pilots are unable to reach emergency controls when necessary.

Finally, we must point out that measurement of cockpit accommodation is not an exact science. Human subjects are quite variable in size, posture, and motivation. We attempt to standardize our methodology to take measurements in a meaningful and repeatable manner that is representative of the manner in which pilots operate their aircraft. For example, because of the great variability in subject sitting postures, we attempt to standardize posture by having the subject sit up straight and look straight ahead during measurement in the aircraft. We are measuring the best "average" posture during typical flight.

However, pilot candidates being tested for entry into flight training will most likely sit much more erect, forcing themselves higher in the cockpit. This is an unlikely posture for normal flying and leaves little if any margin for safety. During measurement of reach to controls, we often lock the shoulder harness and determine reach capability. While there are instructions in many Flight Manual emergency procedures that require the pilot to lock the shoulder harness prior to an event, we also make the assumption that locking the restraint harness inertial reels simulates the restricted mobility a pilot experiences during adverse-G conditions in an emergency situation. Cockpit designers and accommodation researchers have made this assumption for many years. It is the accepted technique for attempting to make a static measure

represent a dynamic one. We also make measurements with locked reels because inadvertent harness locks do occur, and the pilot must be able to control the aircraft until the restraint system is re-cycled.

Finally, anthropometric measurements themselves can be quite variable. Great care and standardization are necessary when making them. If inaccurate measurements are taken on the individual to be classified, the results of the study described here are of little use.

Each section of this report begins with a detailed description of our accommodation research for Training aircraft. Following that is a simple listing of the results for the remaining USAF aircraft we measured. The report format is as follows:

1. the problem being addressed,
2. the operational pass/fail criteria established by AETC for each training aircraft,
3. the methods and assumptions made for each section of the analysis,
4. an explanation of the critical anthropometric variables involved,
5. a list of the results and a discussion of the percentage of the existing pilot population and the JPATS-eligible population expected to experience accommodation problems in each training aircraft.
6. a list of the results for all USAF inventory aircraft.

## 2.0 METHODS

### 2.1 Anthropometric Operational Requirements

The first step in assessing accommodation in an aircraft was to determine what the pilot *must* be able to do to fly the aircraft safely. We call these baseline abilities Anthropometric Operational Requirements. These requirements were established in a six-step process. First, we reviewed T.O.-1 flight manuals for the aircraft and examined all emergency procedures. Next, we interviewed selected instructor and safety pilots to determine a rough set of requirements. At this point, we asked pilots to fly both simulator sorties (to observe emergency procedures) and actual study flights (to determine minimum visual requirements) when possible. Using the results of these initial steps, we created a questionnaire and distributed it to as many experienced pilots as

possible. In the case of training aircraft, we attempted to query 40 pilots at the Instructor Pilot Training School at Randolph AFB, Texas. We used the results of this questionnaire to validate all earlier steps. The final step in the process was to submit the draft list of operational requirements to the appropriate Command headquarters for review and approval. For AETC these requirements were signed by AETC/CC. For the other commands, signatures were obtained from AMC/CC, ACC/DO, and AFSOC/CV. Once these requirements were established, we completed the anthropometric portion of the research. All requirements documents and Staff Summary Sheets are attached as appendices.

### 2.2 Anthropometric Research

Our approach in the anthropometric portion of this research is to use numerous test subjects representing as well as possible the extremes of body sizes within the potential user population. In a sense, we use the subjects as human tools to establish the upper and lower limits of body size accommodation. Each subject is measured both statically and as they perform the list of Anthropometric Operational Requirements in the cockpit. We measure excess and miss distances so we can calculate minimum and maximum capability levels.

Each area of accommodation discussed below may involve different numbers of subjects, depending on the amount of variability we expect. For example, overhead clearance is a straightforward measure in which we add a minimum clearance above the head to the subject's Sitting Height. When the seat is positioned full-down, the subject's Sitting Height plus the clearance space sum to the largest Sitting Height which could be seated with no head clearance. Typically, we average the data from four or five large subjects to arrive at the final value. However, for reach to controls, subject results vary a great deal because of harness fit, strength, motivation, and a number of anthropometric variables. We use a large number of subjects and perform multiple regression analysis to produce the final results for this area of accommodation.

We examined seven aspects of anthropometric accommodation in each aircraft:

8. Overhead clearance.
9. Rudder pedal operation.
10. Internal and external visual field.

11. Static ejection clearances of the knee, leg, and torso with cockpit structures.
12. Operational leg clearances with the main instrument panel.
13. Operational leg clearance with the control stick motion envelope (the pilot's ability to move the stick through its full range of travel).
14. Hand reach to controls.

In some aspects of accommodation (overhead clearance and vision, for example), anthropometric relationships are obvious and fairly simple. Overhead clearances are directly related to Sitting Height. Vision out of the aircraft, especially vision over-the-nose (ONV), is directly related to Sitting Eye Height. For these measures, multiple anthropometric dimensions are unnecessary to explain accommodation levels.

Other measures of accommodation are more complex. For example, operational clearance of the body with the control stick or wheel motion envelope can be restricted as the stick is pulled aft. Often there is not enough room between the thighs to roll the aircraft left and right. This range of motion is influenced by Eye Height Sitting, Thigh Circumference, and Buttock-Knee Length. The relationship between the upper seat positions (used by pilots with a small Sitting Eye Height) and thigh size seems to be the most critical. Stick clearance problems can be visualized by imagining that the motion of the upper end of the control grip is similar to the base of an inverted cone (Figure 2.1).

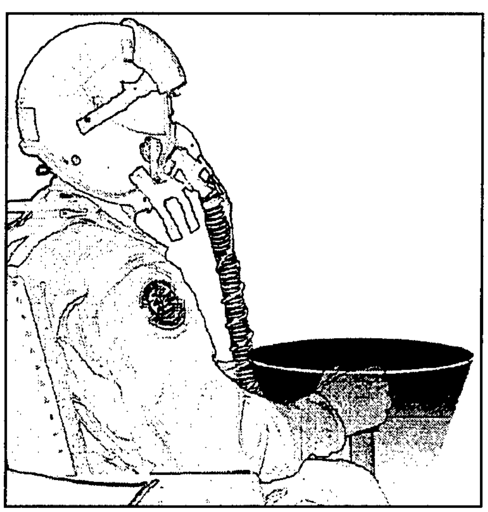

Figure 2.1. The stick motion envelope.

As the pilot raises the seat to improve external vision, the range of stick travel side-to-side increases relative to the pilot's legs. Extremely large pilots typically use the full-down seat position, and the control stick is far above the thighs, reducing or eliminating interference. Small pilots, however, are typically adjusted as high in the seat as possible to gain adequate over-the-nose vision. From this position, the stick often contacts the pilot's thighs. Pilots with long legs are typically able to spread their knees apart, making a greater space available between the thighs for control stick movement. Small pilots, however, may not be able to do this while keeping their feet on the rudder pedals.

For these reasons, we take measurements on subjects of various sizes with the seat adjusted to numerous positions. This allows us to examine accommodation for that subject as well as for other subjects with similar body sizes and proportions. For example, we might find that a subject with a given Shoulder Height misses reaching the landing gear handle by 1.5 inches with the seat full-up. We can assume that another subject with the same Shoulder Height, but with arms 1.5 inches longer, will be just able to reach the landing gear handle from the same seat position. Using this extrapolation procedure in a conservative way, we can use the subjects as tools to predict the accommodation of other subjects close to the same size. To be successful, we have to run many subjects in numerous seat positions to calculate all the combinations of size and seat positions possible for reaching controls. We use a similar approach in examining all aspects of accommodation.

After we collect all the data, we use regression analysis to develop predictive equations for any seat position. The equations describe the combinations of proportions the pilot must have to be accommodated on all criteria. Regression provides a best-fit estimate for the sample measured. It is similar to the "average" answer for a group of people of the same size. These data should therefore be considered good estimates, but not exact data points.

# 3.0 SMALL PILOT ACCOMMODATION

## 3.1 Test Sample

Each subject was equipped in the typical complement of flight gear, except for a helmet, used by AETC. Before measuring their capabilities in the cockpit, we measured each subject for 18 traditional anthropometric dimensions. The test samples were not selected to be representative of the body size distribution of the pilot population. Instead, we selected subjects to represent the extremes of the population and still retain a reasonably normal distribution for each measure. Figure 3.1 compares this sample to the USAF baseline population selected from the 1988 US Army Anthropometric survey (Gordon, 1988, and Zehner, 1996).

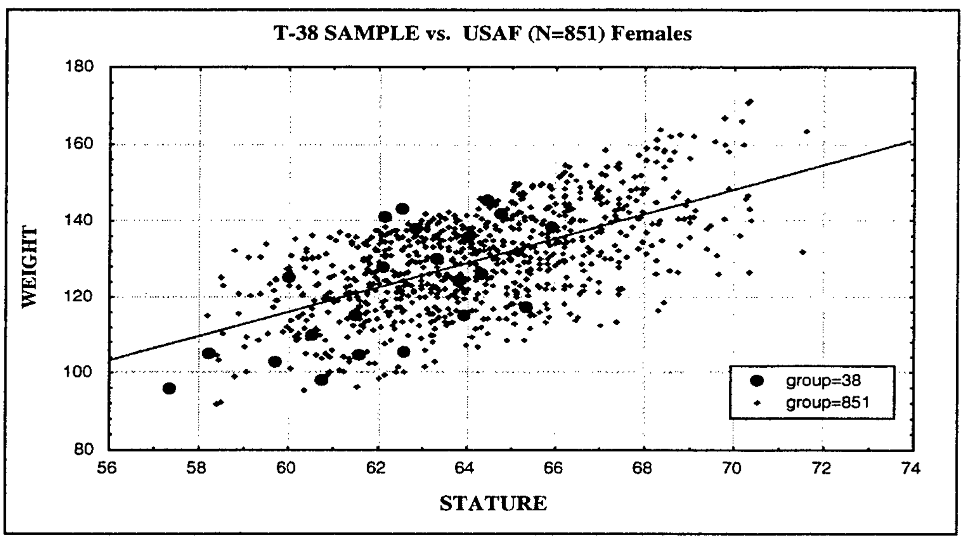


Figure 3.1. Small pilot test sample compared to the USAF baseline population.

## 3.2 Forward Vision over the Nose

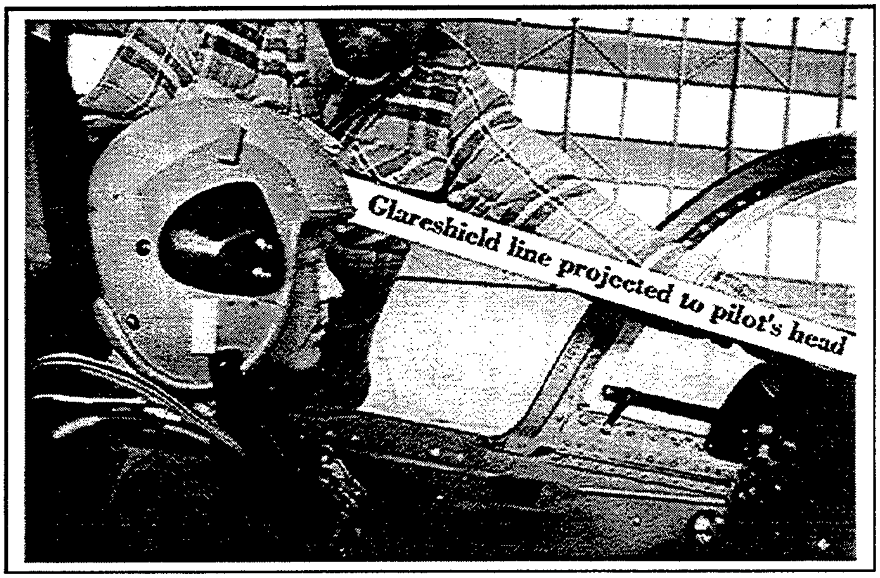


Figure 3.2. JPATS Case 7 in the forward cockpit of the T-38.

### 3.2.1 Problem

For small pilots, external visual field can be so restricted that they cannot see the runway during a landing (especially during a no-flap approach), or may have difficulty seeing their wingman during a formation rejoin. A small subject's eye position may be below the aft edge of the glareshield. If the aircraft is equipped with a HUD, as the T-38C will be, small pilots may not be able to see all of the symbology on the display. Vision requirements for the aircraft listed below were determined during flight testing.

### 3.2.2 Anthropometric Operational Requirements

**T-1:**

Pilots must be able to see the runway during both normal and no-flap approaches without stretching or tilting their head up and back to see over the nose. This equates to a minimum ONV angle of -10 degrees relative to the aircraft waterline.

**T-6:**

Pilots must be able to see the runway during both normal and no-flap approaches without stretching or tilting their heads up and back to see over the nose. This equates to a minimum ONV angle of –7.5 degrees relative to the aircraft waterline.

**T-37:**

Pilots must be able to see the runway during both normal and no-flap approaches without stretching or tilting their heads up and back to see over the nose. This equates to a minimum ONV angle of –8.5 degrees relative to the aircraft waterline.

**T-38:**

Pilots must be able to see the runway during both normal and no-flap approaches without stretching or tilting their heads up and back to see over the nose. In addition, the design point from which a pilot can see all HUD symbology is along a line -11 degrees (down vision) relative to the aircraft water line (T-38C). This level is tangent to the glareshield (see the glareshield line in the picture above). When the pilot is at this level, the pilot can see the base of the pitot tube where it attaches to the nose of the aircraft. AETC instructor pilots direct student pilots to adjust their seat high enough to see that part of the aircraft structure. This standard visual field allows the instructor to describe a standard sight picture that the student should see during various maneuvers. From this position, the student pilot will be able to see the runway during a no-flap landing, and will be able to see his or her wingman during a formation rejoin.

### 3.2.3 Methods

We measured vision in two body postures in the front cockpit and in one posture in the rear. In the front crewstation, we measured over-the-nose vision (ONV) with the subject looking straight ahead over the nose of the aircraft. Subjects were instructed to keep their head level (Frankfurt Plane). After the first measure was completed, we asked subjects to stretch their head and neck up and aft to obtain a better view of the ground, and we repeated the measurement.

In the rear cockpit of the T-38, forward vision over the nose is not possible because of the aircraft design. For forward vision in the rear cockpit, we instructed subjects to lean left and sight down the side of the forward crewstation headbox.

### 3.2.4 Anthropometric Variables

The anthropometric dimension most related to vision over the nose is Sitting Eye Height. This is the measurement from the seated surface (buttocks) to the pupil when the head is in the Frankfurt

Plane (horizontal line of sight). The subject sits erect. The correlation between Sitting Eye Height and ONV is very high.

The Sitting Eye Height range for the current USAF population (both flying and non-flying personnel) is 26.1" through 35.6". The range for current USAF pilots is 28.9" to 35.6". The JPATS specification range is 26.8" to 35.0" (Figure 3.3).

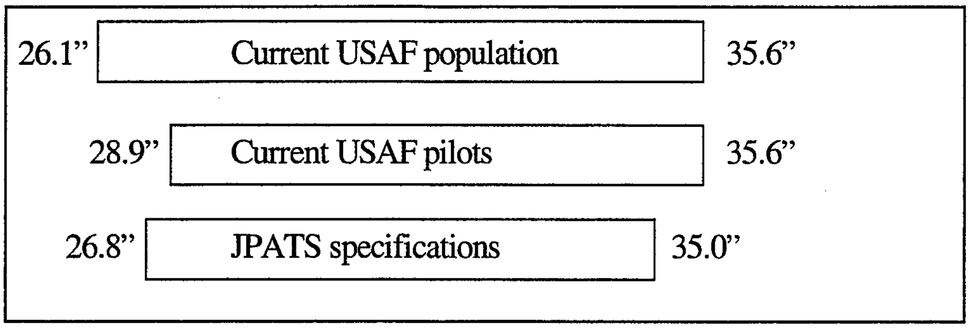


Figure 3.3. Sitting Eye Height ranges for several groups

<u>3.2.5 ONV Results</u>

**T-6:**

A 25-inch Eye Height Sitting (or greater) is necessary to see at least –7.5 degrees over the nose when the seat is adjusted full-up. Since the seat has continuous adjustment any amount of additional Sitting Eye Height is the amount the seat can be lowered. In Table 3.2 we report this as a 1/1 ratio. This will allow the pilot to get closer to the rudders and some hand operated controls.

**T-1:**

A 29.6-inch Eye Height Sitting (or greater) is necessary to see at least –10 degrees over the nose when the seat is adjusted full-up. Since the seat adjusts only in 0.8-inch increments (notches). A pilot has to be at least 0.8 inches larger (a 30.4-inch Sitting Eye Height) to adjust the seat downward one notch and still have –10 degrees ONV. Similarly, the pilot must be at least 1.6 inches larger to go down two notches etc. This will allow the pilot to get closer to the rudders and some controls.

**T-37:**

A 27.5-inch Eye Height Sitting (or greater) is necessary to see at least –8.5 degrees over the nose when the seat is adjusted full-up. Since the seat adjusts in 0.625-inch increments (notches), a pilot has to be at least 0.625 inches larger to adjust the seat downward one notch. Similarly, the pilot must be at least 1.35 inches larger to go down two notches etc. This will allow the pilot to get closer to the rudders and some controls.

**T-38:**

A 29.75-inch Eye Height Sitting (or greater) is required to see at least –11 degrees over the nose when the seat is adjusted full-up. Since the seat has continuous adjustment any amount of additional Sitting Eye Height is the amount the seat can be lowered. This is a 1/1 ratio in Table 3.2.

### 3.2.6 Percentages Effected

There are four samples used in this report to describe the effects of these accommodation limits on different populations. USAF males and females represent our best estimate of the entire USAF population. These groups were selected from the 1988 US Army Anthropometric Survey (Gordon 1988). The samples were selected based on the race, age, and Height/Weight profiles of the USAF population. The male pilot and female pilot samples use this same population, but further restrict it to include only those individuals who meet the Flight training body size requirements listed in AFI 48-123. Table 3.1 lists the percentage of each of these groups fully accommodated on Vision.

Table 3.1. Vision Accommodation Percentages

| Aircraft | USAF Females | Female Pilots | USAF Males | Male Pilots |
|---|---|---|---|---|
| T-1 | 47.1 | 91.2 | 91.4 | 96.2 |
| T-6 | 100.0 | 100.0 | 100.0 | 100.0 |
| T-37 | 93.8 | 100.0 | 99.9 | 100.0 |
| T-38 | 41.7 | 85.7 | 89.6 | 94.3 |

Notice the very high accommodation values for the primary trainers. This was expected for the T-6, due to its design specifications, but not the T-37. The other surprising numbers are the

percentage of the pilot samples that are not accommodated in the follow-on trainers. The table below lists similar data for all USAF aircraft measured.

Table 3.2. Inventory Aircraft Minimum Vision Data

| Aircraft | Minimum. Sitting Eye Height | Additional Eye Height (in.) required to move the seat down | USAF Females | Female Pilots | USAF Males | Male Pilots |
|---|---|---|---|---|---|---|
| T-37 | 27.5 | .625 per notch | 93.8 | 100.0 | 99.9 | 100.0 |
| T-6 | 25.0 | 1/1 * | 100.0 | 100.0 | 100.0 | 100.0 |
| T-1 | 29.6 | .80 per notch | 47.1 | 91.2 | 91.4 | 96.2 |
| T-38 | 29.75 | 1/1 | 41.7 | 85.7 | 89.6 | 94.3 |
| | | | | | | |
| F-16 | 30.2 | 1/1 | 30.5 | 65.6 | 82.8 | 87.6 |
| F-15 | 30.5 | 1/1 | 22.4 | 50.4 | 77.6 | 82.0 |
| A-10 | 29.0 | 1/1 | 64.9 | 99.4 | 96.7 | 99.8 |
| F-117 | 29.6 | 1/1 | 47.1 | 91.2 | 91.6 | 96.2 |
| F-22 | 29.0 | 1/1 | 64.9 | 99.4 | 96.8 | 99.8 |
| | | | | | | |
| TH-67 | 30.0 | Fixed seat | 36.1 | 76.3 | 86.0 | 90.9 |
| UH-1 | 26.6 | .75 per notch | 99.3 | 100.0 | 100.0 | 100.0 |
| MH-60 | 27.8 | .5 per notch | 91.2 | 100.0 | 99.9 | 100.0 |
| MH-53J | 27.0 | .625 per notch | 98.2 | 100.0 | 100.0 | 100.0 |
| | | | | | | |
| B-1B | 27.0 | 1/1 | 98.2 | 100.0 | 100.0 | 100.0 |
| B-2 | 28.5 | 1/1 | 78.7 | 100.0 | 98.8 | 100.0 |
| B-52 | 30.0 | 1/1 | 36.1 | 76.3 | 86.3 | 91.1 |
| | | | | | | |
| C-21 | 26.1 | 1.5 per notch | 99.9 | 100.0 | 100.0 | 100.0 |
| C-130J | 28.0 | .5 per notch | 88.0 | 100.0 | 99.8 | 100.0 |
| C-5 | 28.9 | .47 per notch | 66.5 | 100.0 | 97.1 | 99.9 |
| C-17 | 29.2 | 1/1 | 58.8 | 98.6 | 96.0 | 99.8 |
| KC-10 | 26.1 | 1/1 | 99.9 | 100.0 | 100.0 | 100.0 |
| KC-135 | 27.3 | .5 per notch | 95.9 | 100.0 | 100.0 | 100.0 |
| C-141 | 28.1 | .625 per notch | 86.5 | 100.0 | 99.6 | 100.0 |

## 4.0 REACH TO RUDDERS


Figure 4.1. JPATS case 7 in the forward cockpit of the T-38.

### 4.1 Problem

Like ONV, the ability to reach and actuate rudder pedals is affected by seat position. A pilot with very short legs may lower the seat in order to reach the rudder pedals. At the same time, however, the pilot must maintain minimum vision levels (and therefore, seat position) throughout a mission. Under no circumstances can pilots be allowed to excessively sacrifice external vision. If the pilot candidate has excess Sitting Eye Height based on Table 3.2, the pilot can lower the seat the appropriate amount and maintain acceptable vision out of the aircraft. This will improve access to the rudder pedals.

### 4.2 Anthropometric Operational Requirements

Aircraft seldom require full rudder input when in the air. However, engine out maneuvers, maneuvering on the ground, and being prepared for a blown tire on landing or takeoff, require the ability to apply full rudder and full brake simultaneously.

## 4.3 Methods/Assumptions

We placed the subjects' feet on the rudders with their toes on the brakes. We defined full rudder throw as full rudder input and full brake, with the knee fully extended. The subject was tightly restrained and not allowed to slide forward in the seat. Excessive stretching will not allow pilots to place adequate force on the pedals during an emergency.

## 4.4 Anthropometric Variables

The measurement which best identifies the minimum leg length required to reach full rudder throw is a combined leg length. We add Buttock-Knee Length and Sitting Knee Height to arrive at a new measure that we call "Comboleg." For example, if a 42" combined leg length is required to obtain full rudder throw, it does not matter if a pilot has a 23" Buttock-Knee Length and a 19" Sitting Knee Height or a 22" Buttock-Knee Length and a 20" Sitting Knee Height. Their reach to the rudder pedals will be the same. Using Comboleg would not be appropriate, however, in aircraft where the pilot cannot fully extend his or her knee. If the pilot's knee remains flexed, the relative contribution of thigh and calf may be significant. A multiple regression may be appropriate for such aircraft. The correlation between Comboleg and rudder reach for the T-38 is .96. Other measurements of leg length did not correlate as highly with rudder reach ability.

The current USAF population ranges for Comboleg are 37.8" to 52.4". For current pilots, the range is 40.7" to 52.4". The JPATS range is 38.9" to 52.7" (Figure 4.2).

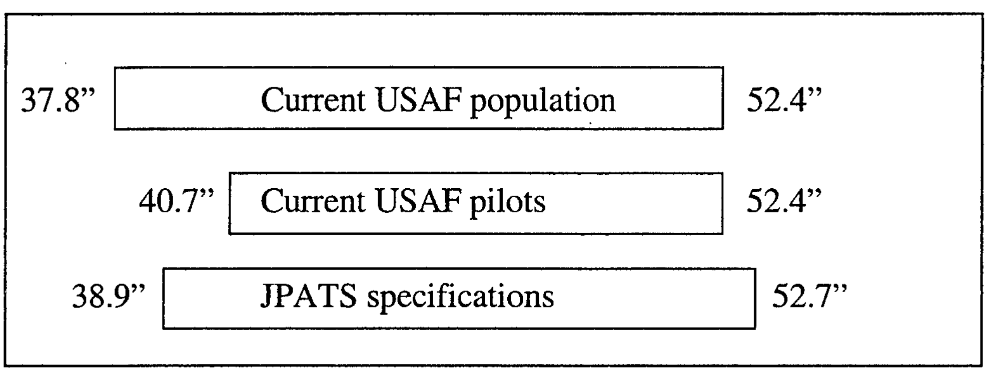


Figure 4.2. Comboleg ranges for several groups

## 4.5 Results for Reach to Rudder Pedals

**T-1:**

A Comboleg of 38.6" is required to apply full rudder and brake with the seat full-up. For each notch the seat can be lowered, the pilot could have a 0.2" shorter Comboleg.

**T-6:**

A Comboleg of 40" is required to apply full rudder and brake with the seat full-up. For each inch the seat can be lowered, the pilot could have a 0.7" shorter Comboleg.

**T-37:**

A Comboleg of 40.5" is required to apply full rudder and brake with the seat full-up. For each notch the seat can be lowered, the pilot could have a 0.25" shorter Comboleg

**T-38:**

A Comboleg of 43" is required to apply full rudder and brake with the seat full-up. For each inch the seat can be lowered, the pilot could have a 0.5" shorter Comboleg.

## 4.6 Percentages Affected

There are four samples used below to describe the effects of these accommodation limits on different populations. USAF males and females represent our best estimate of the entire USAF population. These groups were selected from the 1988 US Army Anthropometric Survey (Gordon 1988). The samples are selected based on the race, age, and Height/Weight profiles of the USAF population. The male and female samples use this same population, but further restrict it to include only those individuals who meet the Flight training body size requirements listed in AFI 48-123. Table 4.1 lists the percentage of each of these groups fully accommodated on Reach to Rudders (when the seat is full-up).

Table 4.1. Rudder Accommodation Percentages

| Aircraft | USAF Females | Female Pilots | USAF Males | Male Pilots |
|---|---|---|---|---|
| T-1 | 99.4 | 100.0 | 100.0 | 100.0 |
| T-6 | 99.6 | 100.0 | 100.0 | 100.0 |
| T-37 | 90.4 | 100.0 | 99.9 | 100.0 |
| T-38 | 45.3 | 81.3 | 95.2 | 96.6 |

Again, accommodation rates for the primary trainers are very high. The T-1 is also very accommodating for reach to Rudders. Also note that 25% of the female pilot sample would have to stretch to reach rudders in the T-38 if it becomes necessary. The table below lists the rudder reach requirements for all USAF aircraft studied.

Table 4.2. Rudder Reach Requirements for USAF Aircraft

| Aircraft | Minimum Comboleg | If Sitting Eye Height is larger than minimum, reduce Comboleg by this amount | USAF Females | Female Pilots | USAF Males | Male Pilots |
|---|---|---|---|---|---|---|
| T-37 | 40.5 | 1 notch (.625") / 0.25 | 90.4 | 100.0 | 99.9 | 100.0 |
| T-6 | 40.0 | 1" / 0.67 | 99.6 | 100.0 | 100.0 | 100.0 |
| T-1 | 38.6 | 1 notch (.8") / 0.2 | 99.4 | 100.0 | 100.0 | 100.0 |
| T-38 | 43.0 | 1" / 0.5 | 45.3 | 81.3 | 95.2 | 96.6 |
| | | | | | | |
| F-16 | 38.5 | 1" / 0.65 | 99.4 | 100.0 | 100.0 | 100.0 |
| F-15 | 38.75 | 1" / 0.7 | 99.2 | 100.0 | 100.0 | 100.0 |
| A-10 | 42.5 | 1" / 0.8 | 60.8 | 97.0 | 98.3 | 99.5 |
| F-117 | 36.25 | 1" / 0.5 | 100.0 | 100.0 | 100.0 | 100.0 |
| F-22 | 40.0 | 1" / 0.5 | 93.2 | 100.0 | 99.9 | 100.0 |
| | | | | | | |
| TH-67 | 41.4 | Seat Fixed | 74.4 | 98.6 | 98.7 | 99.3 |
| UH-1 | 40.75 | 1 notch (.75") / 0.3 | 90.8 | 100.0 | 99.9 | 99.3 |
| MH-60 | 40.6 | 1 notch (.5") / 0.2 | 88.8 | 100.0 | 99.9 | 100.0 |
| MH-53J | 43.5 | 1 notch (.625") / 0.4 | 59.6 | 97.2 | 98.3 | 99.5 |
| | | | | | | |
| B-1B | 37.5 | 1"/ 0.5 | 100.0 | 100.0 | 100.0 | 100.0 |
| B-2 | 41.6 | 1"/ 0.7 | 76.4 | 100.0 | 99.5 | 100.0 |
| B-52 | 42.7 | 1"/ 0.75 | 51.2 | 87.3 | 96.3 | 97.6 |
| | | | | | | |
| C-21 | 38.1 | 1 notch (1.5") / 0.3 | 99.9 | 100.0 | 100.0 | 100.0 |
| C-130J | 38.75 | 1 notch (.5") / 0.2 | 99.4 | 100.0 | 100.0 | 100.0 |
| C-5 | 39.0 | 1 notch (.47") / 0.125 | 98.2 | 100.0 | 100.0 | 100.0 |
| C-17 | 40.6 | 1" / 0.4 | 87.5 | 100.0 | 99.8 | 100.0 |
| KC-10 | 38.9 | 1" / 0.4 | 99.8 | 100.0 | 100.0 | 100.0 |
| KC-135 | 35.6 | 1 notch (.5") / 0.175 | 100.0 | 100.0 | 100.0 | 100.0 |
| C-141 | 41.4 | 1 notch (.625") / 0.15 | 76.6 | 99.7 | 99.3 | 99.9 |

# 5.0 ARM REACH TO CONTROLS


Figure 5.1. JPATS Case 7 in the forward cockpit of the T-38.

## 5.1 Problem

Pilots must be able to reach and operate hand controls to safely fly an aircraft. In normal flight conditions, with the inertial reels unlocked, this is not a difficult task. Under adverse G conditions, however, or when there is an inadvertent reel lockup, small pilots will have difficulty reaching many controls. Only the worst case control for each aircraft is presented here, all measured controls are listed in Appendix C.

## 5.2 Anthropometric Operational Requirements

**T-1:**

AETC determined that, with a locked inertial reel, pilots must be able to operate the inertial reel lock, throttles, emergency brake handle, landing gear lever, and move the yoke to all positions. Throttles are the most difficult of this group to reach, so they are the only control discussed below.

**T-6:**

During source selection AETC determined that, with a locked inertial reel, pilots must be able to operate the controls listed in the tables below.

Table 5.1. Required Controls Operable Under Zones 1 and 2 Conditions T-6

**Required Controls Operable Under Zone 1 Conditions**

| | |
|---|---|
| All primary and secondary in flight escape system controls | Inertial lock manual selector |
| Control stick, rudder pedals, and PCL in neutral position | |

**{PRIVATE }{PRIVATE }Required Controls Operable Under Zone 2 Conditions{tc \f T \l 9 "Table 5B - Required Controls Operable Under Zone 2 Conditions"}**

| | | |
|---|---|---|
| Power Control Levers, Full Operational Range | Control Stick, Full Operational Range | Trim Override |
| Rudder Pedals, Full Operational Range | Emergency Ground Egress Controls | |
| Flaps | Master Caution Cancel | |
| Nose Gear Steering Engage and Disable | Toe Brakes | |
| All Power Control Lever (PCL) and Hands On PCL and Stick (HOTAS) Functions | Speedbrake | |

The Control Stick, Full Operational Range (Zone 2) is the most difficult of this group to reach, so it's the only control discussed here.

**T-37:**

AETC determined that, with a locked inertial reel, pilots must be able to operate the inertial reel lock, the ejection handles, flaps, throttles, and full-forward stick. Full-forward stick is the most difficult of this group to reach, so it's the only control discussed here.

**T-38:**

AETC determined that, with a locked inertial reel, pilots must be able to operate the inertial reel lock, the ejection handles, and retard full-burner throttles. Throttles are the most difficult of this group to reach, so they are the only control discussed here.

## 5.3 Methods/Assumptions

Our reach to controls measurements were based on two harness configurations: reels locked and shoulders against the seat back (Zone 1), and reels locked but with the shoulder stretching out toward the control as far as the restraint will allow (Zone 2). Usually the inertial reels are not locked, but safety concerns dictate examining "worst case" scenarios.

In the Zone-3 configuration, inertial reels were unlocked and subjects were allowed to lean in the direction of the hand controls to reach them. For most cockpits, even our smallest subjects were able to reach all controls on their side of the crew station in a Zone-3 harness configuration. The Zone 2 requirements are much more restrictive.

Finally, factors that affect mobility at the shoulder and elbow, such as design, fit, and adjustment of harnesses, personal protective and survival gear, body strength, and motivation all come into play in the act of reaching. This is the most difficult area of accommodation to accurately quantify.

### 5.4 Anthropometric Variables

Reach to a particular control is a function of arm length, shoulder height, and eye height. Sitting Eye Height again plays a large role in seat adjustment, since the pilot must maintain at least minimally adequate vision. Moving the seat up moves the pilot farther from most controls since the height of the shoulders relative to the control of interest directly influences the pilot's reach ability.

Arm reach is also affected by the width of the shoulders, primarily because of the restraint system. On subjects with narrow shoulders, the torso harness may restrain forward movement of the shoulder. Wide-shouldered subjects, however, are better able to move their shoulders around the outside of the straps while reaching.

To eliminate the need for a regression requiring three predictive variables, we substituted the variable Span for Thumb-Tip Reach and Biacromial Breadth, and created a two variable regression using Span and Sitting Shoulder Height. For some controls, particularly those overhead or on the aft portion of the side consoles, Shoulder Height is a significant variable in the regression equations. However, most of the controls listed above are forward of the shoulder, and the height of the shoulder was not significant in the resulting equations. Therefore, most of the time, only arm span is necessary to predict reach capability.

The Span range for the current USAF population (both flying and non-flying personnel) is 55" to 82". For current pilots, the Span range is 62.8" to 80". The JPATS Span range is 59.7" to 80" (Figure 5.2).

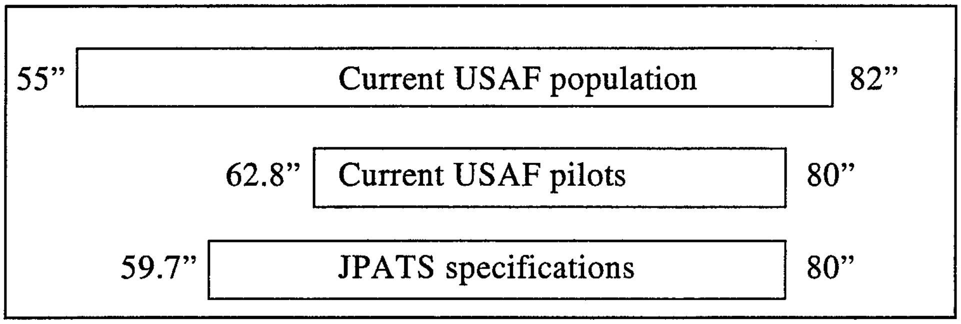


Figure 5.2. Span ranges for several groups

## 5.5 Reach to Controls

**T-1:**

Minimum Span to actuate Throttles = 57.7 inches with seat full-up. For each notch the seat can be lowered, the Minimum Span is reduced by 0.5 inches.

**T-6:**

Minimum Span to actuate forward left stick (operational range) = 60.1 inches with seat full-up. For each inch the seat can be lowered, the Minimum Span is reduced by 0.5 inches.

**T-37:**

Shoulder Height is important in this equation. It takes a 61 inch Span to reach full-forward stick if Shoulder Height = 22 inches. One inch of change in Shoulder Height causes a 0.4-inch change in the minimum Span (a larger Shoulder Height requires a greater span to reach the stick). Each notch the seat can be lowered reduces the minimum Span by 0.28 inches.

**T-38:**

Minimum Span to actuate Throttles = 66.5 inches with the seat full-up. For each inch the seat can be lowered, the Minimum Span is reduced by 0.9 inches.

## 5.6 Percentages Affected

Once again the samples are used below to describe the effects of these accommodation limits on different populations. Table 5.2 lists percentages for those accommodated for reach to controls.

Table 5.2. Arm Span Accommodation Percentages

| Aircraft | USAF Females | Female Pilots | USAF Males | Male Pilots |
|---|---|---|---|---|
| T-1 | 99.5 | 100.0 | 100.0 | 100.0 |
| T-6 | 98.6 | 100.0 | 100.0 | 100.0 |
| T-37 | 96.8 | 100.0 | 100.0 | 100.0 |
| T-38 | 37.3 | 75.2 | 97.1 | 98.7 |

Again, accommodation values for the primary trainers are very high. The T-1 is also very accommodating for reach to Rudders. Also, recall from above that 25% of the female pilot sample would have to stretch to reach rudders in the T-38 if it becomes necessary. The table below lists the results for reach requirements for all USAF aircraft studied.

Table 5.3. Arm reach requirements for remaining USAF aircraft

| Aircraft | Regression Equation. (Acromion Height = acrht) | If Sitting Eye Height is larger than minimum, reduce miss distance by this amount. | USAF Females | Female Pilots | USAF Males | Male Pilots |
|---|---|---|---|---|---|---|
| T-37 | Stick = .38603 * acrht- .70890 * span + 34.4 | 1notch (.625") / 0.28 less miss | 96.8 | 100.0 | 100.0 | 100.0 |
| T-6 | Stick= Min Span 60.1" | 1" / 0.5 | 98.6 | 100.0 | 100.0 | 100.0 |
| T-1 | Throttle = .5468 * span – 31.6 | 1notch (.8") / 0.5 | 99.5 | 100.0 | 100.0 | 100.0 |
| T-38 | Throttle = .3239 * span – 21.6 | 1" / 0.9 | 37.3 | 75.2 | 97.1 | 98.7 |
| | | | | | | |
| F-16 | Throttle = .5328 * span – 32.5 | 1 / 0.77 | 92.8 | 100.0 | 100.0 | 100.0 |
| F-15 | Ebrake/Steer = .3318 * span – 22.6 | 1 / 0.66 | 17.2 | 36.9 | 91.1 | 93.3 |
| A-10 | Canopy Jettison .39154*span – 26.8 | 1 / 0.67 | 28.1 | 61.4 | 94.9 | 97.3 |
| F-117 | Drag Chute = .6256 * span – 39.7 | 1 / 0.5 | 67.7 | 96.4 | 99.7 | 99.8 |
| F-22 | Gear ovrd = 14.8 + .83939 * acrht - .515 * span | 1 / 0.7 | 62.2 | 87.3 | 99.1 | 99.3 |
| | | | | | | |
| TH-67 | Min Span = 60" | Seat fixed | 96.5 | 100.0 | 100.0 | 100.0 |
| UH-1 | Collective = 6.8 +0.7 * acrht -.334 * span | 1notch (.75") / 0.5 | 80.8 | 98.1 | 99.8 | 99.8 |
| MH-60 | Throttle = 24.8 - .412 * span. Add 1.3" to miss if wearing body armor | 1notch (.5) / 0.3 further away | 67.3 | 95.3 | 99.2 | 99.4 |
| MH-53 | Collective = 55.43 + .41327 * acrht – 1.0 * span | 1notch (.625) / 0.4 | 69.7 | 97.8 | 99.8 | 99.9 |
| | | | | | | |
| B-1 | Stick FFL = 16.0 +.5396*acrht - .41974 * span | 1 / 0.5 | 63.5 | 95.0 | 99.4 | 99.7 |

Table 5.3. Arm reach requirements for remaining USAF aircraft (continued)

| | | | | | | |
|---|---|---|---|---|---|---|
| B-2 | Stick FFL = 7.5 +.61343 * acrht - .33144 * span | 1 / 0.7 | 87.0 | 99.2 | 100.0 | 100.0 |
| B-52 | FF Yoke = 21.8 + .6578 * acrht - .54599 * span | 1 / 0.4 | 26.9 | 46.0 | 91.8 | 93.1 |
| | | | | | | |
| C-21 | < 60" Span | n/a | N/A | N/A | N/A | N/A |
| C-130J | 64" minimum span for Inertial reel lock in E model and all Fire T Handles | 1 notch (.5) / 0.25 further away for Fire T Handle | 61.3 | 96.7 | 99.6 | 99.8 |
| C-5 | 60.9" minimum span for dual reach – Caster and Nose Wheel Steering | n/a | 93.2 | 100.0 | 100.0 | 100.0 |
| C-17 | Uarrsi Handle Z3 =84" total ACR+Span | 1" / 0..25 | 84.2 | 100.0 | 99.9 | 100.0 |
| KC-10 | Fire Handle= 83" total acrht + span | 1" / 0.4 *further away* | 88.0 | 100.0 | 100.0 | 100.0 |
| KC-135 | Co-pilot throttle = .5329 * span – 33.2 | 1 notch (.5) / 0.2 | 87.2 | 100.0 | 100.0 | 100.0 |
| C-141 | Fire T = .699 * span – 45.46 | 1 notch (.625) / 0.3 | 54.9 | 93.4 | 99.4 | 99.8 |

## 6.0 STICK INTERFERENCE WITH THE THIGH

For small pilots, pulling the stick full aft and moving it left and right (roll) can be difficult. When the seat is full-up, there is very little space between the pilot's thighs for stick roll authority. This problem is made worse if the pilot has short legs. Reach to rudders can be so difficult that the pilot is unable to spread the thighs apart to make room for adequate control stick motion. Stick movement problems can also occur for pilots with very large legs, particularly for pilots who also have a short Sitting Height.

### 6.1 Stick Interference Results

In our analyses, the relationship between body size measures and stick/thigh interference was unclear. The correlation between anthropometric measures and stick/yoke interference problems was near zero. However, for many subjects tested with the seat full-up, roll movement was restricted by one to two inches. At this time, pilot candidates must demonstrate full stick/yoke authority prior to take-off.

While we cannot predict this problem based on body types at this point, this discussion is included because the problem may get worse if the aircraft is modified. If the seat is modified to move pilots higher to improve vision or farther forward in the seat to improve reach capability, their relationship with the control stick or yoke changes. Therefore, any change to the seat in aircraft must be followed by careful examination of possible stick interference problems.

## 7.0 LARGE PILOT ACCOMMODATION

### 7.1 Overhead Clearance

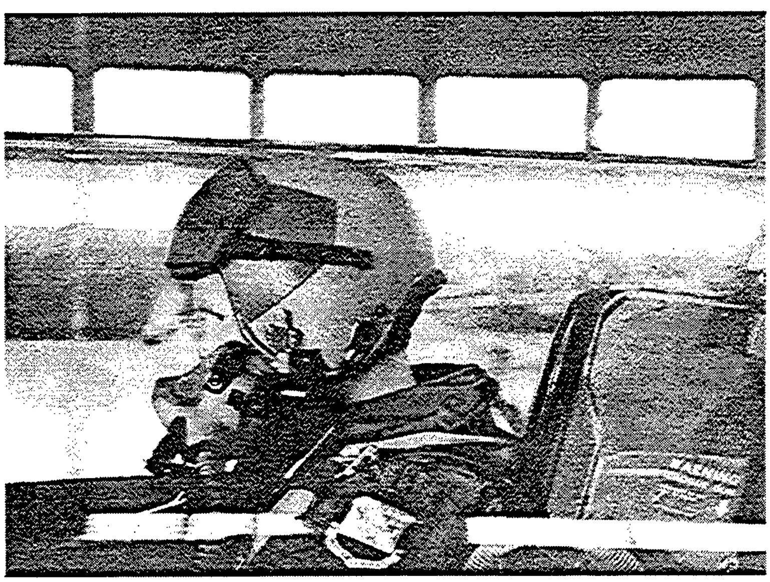

Figure 7.1. Large pilot in the aft cockpit of the T-38.

## 7.2 Problem

Inadequate overhead clearance in an aircraft can be an ejection hazard. If the pilot is unable to sit erect with the head firmly in contact with the seat headbox, or if his or her head is higher than the canopy breakers, the pilot could be injured during ejection.

Also, the pilot's general mobility and capability to look rearward and "check six" are greatly reduced when the pilot's helmet is in contact with the canopy. Both of these problems are exaggerated when the aircraft is inverted.

## 7.3 Assumptions

During these measurements, the subject sat erect with his or her head held in the Frankfurt Plane (horizontal line of sight). We measured the space between the top of the head and the underside of the canopy. We also verified that the subject has enough clearance space to place his or her head fully into the head box prior to ejection, and has sufficient side space for checking for other aircraft directly behind (the "six" position).

Since helmet designs in the military are subject to change, we measured head clearance two ways: bareheaded and with the HGU-55/P (the current flight helmet). When a new helmet comes into the inventory, the HGU/55P data will become obsolete, and will need to be replaced. The bareheaded data must then be used with new measurements taken to describe the change in maximum Sitting Height caused by the new helmet. This dimension must be measured and subtracted from the bareheaded clearance values listed here.

## 7.4 Operational Requirements

AETC determined pilots must have head-to-canopy clearance. No static contact is acceptable. Typically, pilots place a closed fist on top of their helmet and adjust the seat until their hand touches the canopy. This equates to roughly 3.5" of clearance space. We do not use this clearance value in our measurements, but if the USAF adopts an official head-to-canopy clearance value, we can apply it to our data.

## 7.5 Anthropometric Variables

Sitting Height is the only anthropometric variable of interest for overhead clearance. The correlation between Sitting Height and Overhead Clearance is -.92. The range of Sitting Heights in the general military population is 29" through 42". USAF Instruction 48-123 only permits pilots 34" through 40" in Sitting Height to enter UPT. The JPATS range is 31" to 40". The largest Sitting Height of the JPATS cases is 40" (Figure 7.2).

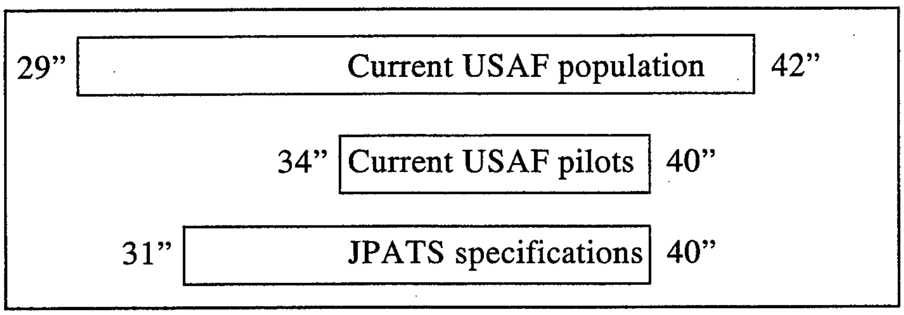


Figure 7.2. Sitting Height ranges for several groups

## 7.6 Results for Overhead Clearance

**T-1:**

For the T-1 cockpit, the largest Sitting Height that can fit (without a helmet) with the seat full-down is 43.4". This is an extremely large value. No one will have overhead clearance problems in the cockpit of the T-1.

**T-6:**

For the T-6's front cockpit, the largest Sitting Height that can fit under the canopy without a helmet and with the seat full down is 46.6". With the HGU-55/P helmet, the value is reduced by 1.5", to 45.1". However, the pilot's head must be below the canopy breakers. During source selection, it was determined that placing the pilot's fist on top of the helmet was a reasonable approach for establishing clearance. This method subtracts 3.5 inches (the average fist breadth) from the maximum Sitting Height. The final value for maximum Sitting height is 41.9 inches. In the aft cockpit it is 41.5 inches. These are large values. No USAF pilot should have overhead clearance problems in the cockpit of the T-6.

**T-37:**

For the T-37 cockpit, the largest Sitting Height that can fit under the canopy without a helmet and with the seat full down is 42.4". With the HGU-55/P helmet, the value is reduced by 1.5", to 40.9". These are large values. No USAF pilots should have overhead clearance problems in the cockpit of the T-37.

**T-38:**

For the T-38's front cockpit, the largest Sitting Height that can fit under the canopy without a helmet and with the seat full-down is 48.5". With the HGU-55/P helmet, the value is reduced by 1.5", to 47". These are extremely large values. No one will have overhead clearance problems in the front cockpit of the T-38. The rear cockpit maximum Sitting Height values with the seat full down are 41.5" bareheaded, and 40.0" with the HGU-55/P helmet. Some pilot's helmets will touch the canopy in the rear cockpit, and will press hard against the canopy during inverted or negative-G flight. Since clearance in the aft cockpit primarily affects instructor pilots, AETC may need to consider a Sitting Height restriction of somewhat less than 40" for instructor pilots.

If additional clearance space is required between the pilot's head and the canopy, that amount should be subtracted from the maximum Sitting Height values.

## 7.7 Percentages Affected

Only the rear cockpit of the T-38 has overhead clearance problems.

**T-38:**

In the front cockpit, no pilot will have overhead clearance problems. In the aft cockpit, the helmets of the tallest current pilots (40" Sitting Height) and JPATS Case 5 will contact the canopy. This group of tallest pilots makes up less than 1% of the pilot population. During inverted flight, however, pilots with Sitting Heights of somewhat less than 40" will likely contact the canopy. If the fist-on-the-helmet approach is used as a minimum clearance requirement in the aft cockpit of the T-38, 3.5" must be subtracted from the 40" maximum, resulting in a maximum Sitting Height of 36.5". Forty-five percent of the male pilot population has a Sitting Height greater than 36.5". This is clearly an extremely limiting requirement. The affected percentages in Table 7.1 below are listed in increments of one-inch clearance space.

Table 7.1. Percentage of pilots having inadequate clearance space in the aft cockpit of the T-38.

| Clearance | 0" | 1" | 2" | FIST (3.5") |
|---|---|---|---|---|
| Percent affected | .3% | 1.6% | 10% | 45% |

Results for overhead clearance in all USAF aircraft are listed below.

Table 7.2. Maximum Sitting Heights for all USAF aircraft studied

| Aircraft | Max Sitting Height With HGU 55/P Helmet (1.5") | USAF Females | Female Pilots | USAF Males | Male Pilots |
|---|---|---|---|---|---|
| **T-37** | 40.9 | 100.0 | 100.0 | 100.0 | 100.0 |
| **T-6** | 41.5 | 100.0 | 100.0 | 100.0 | 100.0 |
| **T-1** | 43.4 | 100.0 | 100.0 | 100.0 | 100.0 |
| **T-38** | 40.0 (aft cockpit) | 100.0 | 100.0 | 99.8 | 100.0 |
| | | | | | |
| **F-16** | 39.7 (includes 2.25" clearance space) | 100.0 | 100.0 | 99.5 | 99.8 |
| **F-15** | 44.1 | 100.0 | 100.0 | 100.0 | 100.0 |
| **A-10** | 43.6 | 100.0 | 100.0 | 100.0 | 100.0 |
| **F-117** | 43.5 | 100.0 | 100.0 | 100.0 | 100.0 |
| **F-22** | 43.4 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | | | |
| **TH-67** | 40.0 | 100.0 | 100.0 | 99.8 | 100.0 |
| **UH-1** | 42+ | 100.0 | 100.0 | 100.0 | 100.0 |
| **MH-60** | 42+ | 100.0 | 100.0 | 100.0 | 100.0 |
| **MH-53J** | 41.5 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | | | |
| **B-1** | 44.4 | 100.0 | 100.0 | 100.0 | 100.0 |
| **B-2** | 55.3 | 100.0 | 100.0 | 100.0 | 100.0 |
| **B-52** | 53 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | | | |
| **C-21** | 39 | 100.0 | 100.0 | 98.2 | 98.4 |
| **C-130J** | 42+ | 100.0 | 100.0 | 100.0 | 100.0 |
| **C-5** | 42+ | 100.0 | 100.0 | 100.0 | 100.0 |
| **C-17** | 42+ | 100.0 | 100.0 | 100.0 | 100.0 |
| **KC-10** | 42+ | 100.0 | 100.0 | 100.0 | 100.0 |
| **KC-135** | 42+ | 100.0 | 100.0 | 100.0 | 100.0 |
| **C-141** | 42+ | 100.0 | 100.0 | 100.0 | 100.0 |

# 8.0 LEG CLEARANCE

We made two measurements for leg length accommodation in the aircraft: ejection clearance and operational clearance.

## 8.1 Ejection Clearance: Clearance to the Canopy Bow

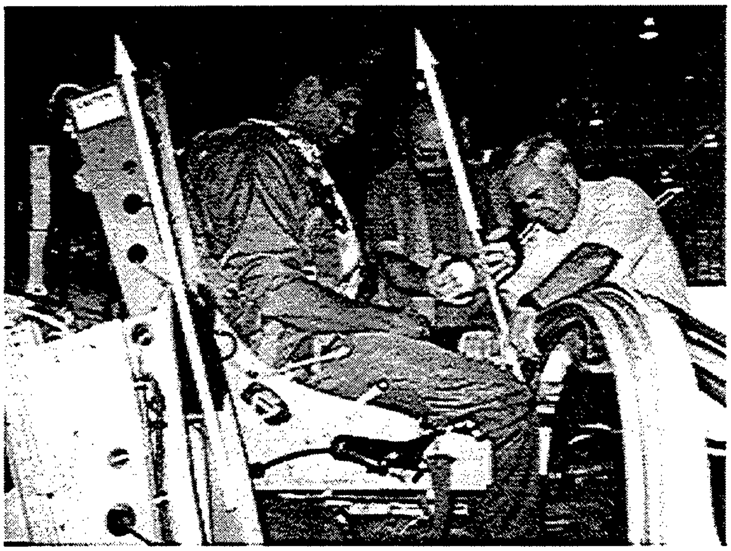

Figure 8.1. Measuring Ejection clearance to the canopy bow

### 8.1.1 Problem

We measured clearances for escape to the Canopy Bow to ensure the pilot does not strike the bow during ejection. Ejection clearance in this case is unaffected by seat position. A safety margin of at least 1" should be considered given the possibility of sliding the legs closer to forward structures as the ejection seat fires. This is discussed below.

### 8.1.2 Operational Requirement

Pilot contact with cockpit structures during ejection is unacceptable.

### 8.1.3 Methods/Assumptions

In our measurements, the seat is placed full-up, the thighs forced down into the seat cushion and the subject is firmly restrained in the seat. This is the best possible ejection position. In an emergency, however, the pilot may be in a less-than-perfect position during ejection. We take this measurement by measuring the distance from the knee to the canopy bow at the point where

the knee would pass the bow during ejection. When we determine that clearance may be a problem, the seat is pulled up the rails to make a more precise measurement.

We made conservative assumptions for other areas of accommodation, but our assumption for ejection clearance is not as conservative as we would like. Dynamic parameters, such as *submarining* beneath the restraints and thigh compression into the seat cushion during ejection, have not yet been quantified. If these parameters are defined at a later date and it is determined that, for example, one inch of static clearance prior to ejection is necessary to avoid leg injury during ejection, that value can be subtracted from the static maximum leg length to arrive at an improved maximum leg length.

### 8.1.4 Anthropometric Variables

The anthropometric measurements of interest for canopy bow clearance are Buttock-Knee Length and Sitting Knee Height. A reasonable expected range of values for the general military population for Buttock-Knee length is 19" to 28.5". For Sitting Knee Height, a range for the general military population is 15.5" to 26.5". For the current USAF flying population, these ranges are 20" to 28" for Buttock-Knee length, and 18.5" to 25.5" for Sitting Knee Height. For JPATS Case 6, the leg length values are 27.9" for Buttock-Knee Length and 24.8" for Sitting Knee Height.

### 8.1.5 Results

**T-1: N/A**

**T-6:**

No current pilot will strike the canopy bow if reasonably positioned in the seat. The maximum static Buttock-Knee Length to clear the canopy bow in the front cockpit of the T-6 is 29.0". For the rear cockpit, it is over 30".

**T-37:**

The T-37 does not have adequate clearance to the canopy bow. A maximum Buttock-knee length of 27.3 inches has been imposed in AFI 48-123. Longer legs are at risk of contact. This value allows one inch of clearance between the knee and the canopy bow if the pilot is sitting properly.

**T-38:**

No current pilot will strike the canopy bow if reasonably positioned in the seat. The maximum static Buttock-Knee Length to clear the canopy bow in the front cockpit of the T-38 is 30.8". For the rear cockpit, it is 32.8".

8.2 Operational Clearance: Shin Clearance to the Instrument Panel

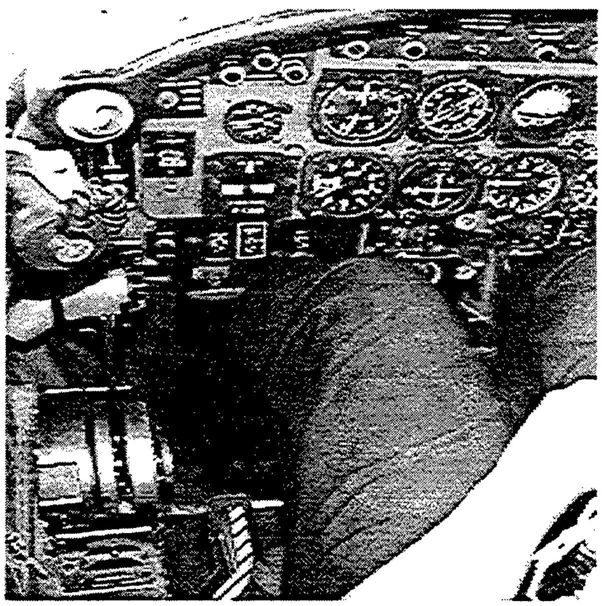

Figure 8.2. Large pilot with poor shin clearance in the T-37.

8.2.1 Problem

A number of aircraft cockpits provide inadequate clearance for the pilot's shins. A number of ejection injuries are related to this dimension. We measure operational clearance forward from the shin to the bottom edge of the main instrument panel to ensure the pilot has space to operate the rudders, and to ensure ejection clearance with the main instrument panel.

8.2.2 Operational Requirements

The pilot must be able to operate the foot pedals and cannot be at risk for injury during ejection.

8.2.3 Methods/Assumptions

We made these clearance measurements with the subject's feet positioned on neutral rudders, as well as while the subject applied full rudder input. We measured clearances on both the active

and passive leg. The rudder carriage was adjusted forward, as far away from the subject as possible. The subject was positioned and restrained firmly in the seat.

8.2.4 Results

**T-1:**

Static shin contact with the instrument panel will not occur until Buttock-Knee length exceeds 27.4". Very few current pilots will hit the instrument panel in this aircraft when reasonably positioned in the seat.

**T-6:**

Static shin contact with the instrument panel will not occur until Buttock-Knee length exceeds 27.9". Very few current pilots will hit the instrument panel in this aircraft when reasonably positioned in the seat.

**T-37:**

Static shin contact with the instrument panel will not occur until Buttock-Knee length exceeds 27.6". Very few current pilots will hit the instrument panel in this aircraft when reasonably positioned in the seat.

**T-38:**

Static shin contact with the instrument panel will not occur until Buttock-Knee length exceeds 30.75". No current pilot will hit his or her shins on the instrument panel in this aircraft when reasonably positioned in the seat. The table below lists the maximum Buttock-knee length for all USAF aircraft studied. These data represent clearance to the closest obstacle (Canopy Bow, Glare shield, or Instrument panel).

Table 8.1. Maximum Buttock-Knee Length for all USAF aircraft studied.

| Aircraft | Maximum Buttock-Knee Length to Contact | USAF Females | Female Pilots | USAF Males | Male Pilots |
|---|---|---|---|---|---|
| **T-37** | 27.3 | 100.0 | 100.0 | 99.9 | 100.0 |
| **T-6** | 27.9 | 100.0 | 100.0 | 100.0 | 100.0 |
| **T-1** | 27.4 | 100.0 | 100.0 | 99.9 | 100.0 |
| **T-38** | 30.8 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | | | |
| **F-16** | 27.1 | 100.0 | 100.0 | 99.9 | 100.0 |
| **F-15** | 27.2 | 100.0 | 100.0 | 99.9 | 100.0 |
| ***A-10*** | 26.7 | 100.0 | 100.0 | 99.4 | 99.4 |
| **F-117** | 28.2 | 100.0 | 100.0 | 100.0 | 100.0 |
| **F-22** | 27.9 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | | | |
| **TH-67** | 27.9 | 100.0 | 100.0 | 100.0 | 100.0 |
| **UH-1** | 28+ | 100.0 | 100.0 | 100.0 | 100.0 |
| **MH-60** | 26.9 | 100.0 | 100.0 | 99.5 | 99.6 |
| **MH-53J** | 28+ | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | | | |
| **B-1** | 28 | 100.0 | 100.0 | 100.0 | 100.0 |
| **B-2** | 30.6 | 100.0 | 100.0 | 100.0 | 100.0 |
| **B-52** | 28.4 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | | | |
| **C-21** | 26.3 | 100.0 | 100.0 | 97.8 | 97.8 |
| **C-130J** | 28+ | 100.0 | 100.0 | 100.0 | 100.0 |
| **C-5** | 28+ | 100.0 | 100.0 | 100.0 | 100.0 |
| **C-17** | 28+ | 100.0 | 100.0 | 100.0 | 100.0 |
| **KC-10** | 28+ | 100.0 | 100.0 | 100.0 | 100.0 |
| **KC-135** | 28+ | 100.0 | 100.0 | 100.0 | 100.0 |
| **C-141** | 28+ | 100.0 | 100.0 | 100.0 | 100.0 |

*=WORST CASE EJECTION SEAT AIRCRAFT

# 9.0 FINAL ACCOMMODATION PERCENTAGES

Four groups are used in the tables below to demonstrate the effects of accommodation problems on the USAF population. The USAF male and USAF female samples were selected from the 1988 US Army Anthropometric Survey (Gordon 1988) to represent the Age, Race, and Height/Weight profiles of the Air Force population. Those same samples were then reduced by applying the body size restrictions for entering flight training (AFI 48-123), which includes the T-37 Buttock Knee Length restriction. Only those people large enough to pass pilot size restrictions are described. A percentage of both male and female samples were excluded in nearly all of the accommodation areas discussed above, so we calculated the overall accommodation percentage for the aircraft. Failure on any one of the accommodation criteria could make a pilot unsafe to fly an aircraft.

## 9.1 Small Pilots

Table 9.1. Percentages of small people accommodated in training aircraft

| Aircraft | USAF Female Population | Female Pilot Population | USAF Male Population | Male Pilot Population |
|---|---|---|---|---|
| **T-1** | 47.1 | 91.2 | 91.6 | 96.2 |
| **T-6** | 98.6 | 100.0 | 100.0 | 100.0 |
| **T-37** | 86.3 | 100.0 | 99.9 | 100.0 |
| **T-38** | 27.2 | 63.4 | 86.9 | 91.8 |

Results for final accommodation of small pilots in all USAF aircraft are listed below.

Table 9.2. Total Small Pilot Accommodation for all USAF aircraft studied.

| Aircraft | USAF Females | Female Pilots | USAF Males | Male Pilots |
|---|---|---|---|---|
| **T-37** | 86.3 | 100.0 | 99.9 | 100.0 |
| **T-6** | 98.6 | 100.0 | 100.0 | 100.0 |
| **T-1** | 47.1 | 91.2 | 91.6 | 96.2 |
| **T-38** | 27.2 | 63.4 | 86.9 | 91.8 |
| | | | | |
| **F-16** | 30.5 | 65.6 | 82.9 | 87.6 |
| **F-15** | 12.2 | 28.4 | 75.5 | 79.7 |
| **A-10** | 27.7 | 61.2 | 92.9 | 97.0 |
| **F-117** | 41.6 | 87.9 | 91.3 | 96.1 |
| **F-22** | 45.9 | 86.8 | 96.0 | 99.2 |
| | | | | |
| **TH-67** | 33.8 | 75.2 | 85.7 | 90.6 |
| **UH-1** | 78.2 | 98.1 | 99.7 | 99.8 |
| **MH-60** | 63.9 | 95.3 | 99.2 | 99.4 |
| **MH-53J** | 56.3 | 95.9 | 98.2 | 99.4 |
| | | | | |
| **B-1** | 63.0 | 95.0 | 99.4 | 99.7 |
| **B-2** | 65.2 | 99.2 | 98.5 | 100.0 |
| **B-52** | 15.3 | 35.5 | 81.1 | 85.7 |
| | | | | |
| **C-21** | 99.8 | 100.0 | 100.0 | 100.0 |
| **C-130J** | 60.1 | 96.7 | 99.4 | 99.8 |
| **C-5** | 64.8 | 100.0 | 97.1 | 99.9 |
| **C-17** | 56.4 | 98.6 | 95.9 | 99.8 |
| **KC-10** | 88.0 | 100.0 | 100.0 | 100.0 |
| **KC-135** | 85.0 | 100.0 | 100.0 | 100.0 |
| **C-141** | 51.9 | 93.1 | 98.7 | 99.7 |

## 9.2 Large Pilots

No females in the sample were too large to fit in these aircraft. Only male data are reported in Table 9.3.

Table 9.3. Percentages of large people accommodated in training aircraft

| Aircraft | USAF Male Population | Male Pilot Population |
|---|---|---|
| **T-1** | 99.9 | 100.0 |
| **T-6** | 100.0 | 100.0 |
| **T-37** | 99.9 | 100.0 |
| **T-38** | 99.7 | 100.0 |

**T-38:**

A small percentage of large pilots will contact the canopy in the rear cockpit, so a minimum overhead clearance value should be established. Our recommendation is 1". A 1" clearance requirement would eliminate 1.6% of current pilots and 2.2% of the JPATS male population from becoming instructor pilots.

Results for final accommodation of large pilots in all USAF aircraft are listed below.

Table 9.4. Total Large Pilot Accommodation for all USAF aircraft studied.

| Aircraft | USAF Males | Male Pilots |
|---|---|---|
| **T-37** | 99.9 | 100.0 |
| **T-6** | 100.0 | 100.0 |
| **T-1** | 99.9 | 100.0 |
| **T-38** | 99.7 | 100.0 |
| | | |
| **F-16** | 99.3 | 99.7 |
| **F-15** | 99.9 | 100.0 |
| **A-10** | 99.1 | 99.1 |
| **F-117** | 100.0 | 100.0 |
| **F-22** | 100.0 | 100.0 |
| | | |
| **TH-67** | 99.7 | 100.0 |
| **UH-1** | 100.0 | 100.0 |
| **MH-60** | 99.5 | 99.6 |
| **MH-53J** | 100.0 | 100.0 |
| | | |
| **B-1** | 100.0 | 100.0 |
| **B-2** | 100.0 | 100.0 |
| **B-52** | 100.0 | 100.0 |
| | | |
| **C-21** | 95.8 | 95.9 |
| **C-130J** | 100.0 | 100.0 |
| **C-5** | 100.0 | 100.0 |
| **C-17** | 100.0 | 100.0 |
| **KC-10** | 100.0 | 100.0 |
| **KC-135** | 100.0 | 100.0 |
| **C-141** | 100.0 | 100.0 |

# 10.0 SUMMARY OF RESULTS

## 10.1 Trainers

Our investigation of USAF trainer aircraft indicates:

Small Pilot Candidates:

Of the aircraft examined (T-6, T-37, T-1, and T-38), the primary trainers (T-6, and T-37) are very accommodating. Many pilots smaller than current size requirements listed in AFI 48-123 (Height 64 - 77 inches, Sitting Height 34 – 40 inches, Maximum Buttock-Knee length – 27.3 inches) could pilot these aircraft. However, for the follow-on Trainers that is not the case. In the T-1, small pilots with short Sitting Eye Heights will have difficulty seeing the runway in a no-flap landing. Also, when the seat is adjusted full-up, they may have interference between the yoke (during roll) and their thighs. Pilots with very short arms and legs could be assigned to this aircraft if their Eye Height is adequate.

The T-38A does not accommodate small pilots well at all. They have problems with vision over the nose, reach to rudders, and arm reach to controls. Pilots smaller than current requirements in AFI 48-123 should not be assigned to this aircraft.

The only apparent possibility for easing size restrictions for small candidates would be if the USAF were to pre-select candidates for the T-1 track.

Large Pilot Candidates:

For large pilots, a more complex situation exists. In the primary trainers, Sitting Heights over 40 inches (the current maximum) are accommodated by the T-6 (41.5") and T-37 (40.9"). Those with very long Buttock-knee lengths (larger than the 27.3-inch T-37 restriction) could be assigned to the more accommodating T-6. The T-6 will accommodate Buttock-Knee lengths up to 27.9 inches.

Of the follow-on trainers, the T-38 generally accommodates large pilots well. Any leg lengths accommodated in the T-37 or T-6 will be accommodated in the T-38A. The only T-38A large

pilot accommodation problem is overhead clearance in the aft cockpit (Maximum = 40 inches). Pilots at the current limit for Sitting Height will experience head contact with the canopy. Pilots with Sitting Heights larger than 40 inches should not be permitted in the aft cockpit.

The T-1 accommodates large pilots fairly well, but Buttock-Knee lengths over 27.4 inches will be in contact with the instrument panel. This is not an injury risk as it is in trainers with ejection seats. Pilots with very large Sitting Heights (43.4") are accommodated in the T-1.

In summary, Pilots with Sitting Heights larger than 40" could be sent through T-6 or T-37 to the T-1. Pilots with Buttock-Knee lengths larger than 27.3" should only go through the T-6, and then, only to the T-38.

Training aircraft assignments are only the beginning of this issue. Individuals outside AFI-48-123 will have to be selectively assigned to follow-on USAF aircraft as well. Some are very accommodating - others are not.

## 10.2 Fighters

Small Pilot Candidates:

The T-38 remains an accommodation bottleneck for entry into Fighter aircraft. However, even if the T-38 is modified to improve accommodation, accommodation levels in the remaining Fighter Aircraft do not warrant relaxing size requirements. For small pilot candidates: Vision over the nose is a problem primarily in the F-16 and F-15, but all Fighters require a Sitting Eye Height of over 29 inches (near current small pilot size). Arm reach to controls is difficult in the A-10 (Canopy Jettison) and F-15 (Emergency Brake/Steering) and to a lesser extent the F-117 (Drag Chute). These reaches are difficult for current small pilots. Reach to Rudders is only difficult in the A-10. Some current small pilots (those who meet 48-123 requirements) will not be able to meet all functional anthropometric requirements set by ACC. Smaller pilots should not be assigned to Fighter aircraft.

Large Pilot Candidates:

Overhead clearance in the F-16 is reduced because of deformation of the canopy during a bird

strike. A 39.7" Sitting Height is accommodated. Also, the F-16 has limited leg clearance to the main instrument panel. A-10 and F-15 also have limited legroom. It does not appear that pilots larger than current requirements can be assigned to fighter aircraft in general.

### 10.3 Bombers

Small Pilot Candidates:

Again, the T-38 is a bottleneck preventing smaller pilot candidates from being assigned to Bomber aircraft. However, the required arm reaches for all three aircraft, and the reach to rudder requirements for B-2 and B-51 make it unwise to assign smaller pilots to these aircraft.

Large Pilot Candidates:

If large pilots are able to train in the T-38 they will not have size problems in Bomber aircraft. Accommodated Sitting Heights are 44.4 inches and up. Leg lengths of 28 inches and higher are accommodated as well.

### 10.4 Helicopters

Small Pilot Candidates:

After primary training in the T-6 or T-37, USAF helicopter pilots are sent to the US Army for primary helicopter training in the TH-67. Unfortunately, this is not a very accommodating aircraft for vision over the nose (30"Sitting Eye Height) or for reach to rudders (41.4" Leg length).

The USAF Helicopters are very accommodating for Sitting Eye Height (26.6" – 27.8" minimums), but arm reaches in H-1 and H-53 require around a 64" Span. Reach to rudders is difficult in the H-53 (43.5" leg length needed).

Given the combination of the TH-67 Sitting Eye Height and the Leg and arm reaches needed in the H-53, assigning smaller pilot candidates to Helicopters does not seem to be a viable option at this time.

Large Pilot Candidates:

Pilots with Sitting Heights larger than 40 inches should not be sent through the TH-67. However, USAF Helicopters are accommodating for large Sitting Heights (41.5" – 42+"). The

TH-67, H-1, and H-53 are accommodating for Buttock-Knee length, but the H-60 has a maximum Buttock-Knee length of 26.9" before contact is made with the main instrument panel. Helicopters do not appear to be an acceptable assignment track for candidates larger than current size requirements.

## 10.5 Heavy Aircraft

Heavy aircraft have seats that move up/down and fore/aft. In addition, most have tilting seat back angles. These aircraft do not land at high angles-of-attack the way fighters do, and do not pull significant G forces. As a result, the requirements to reach controls with a locked harness inertial reel are very small. These aircraft can in general accommodate a much wider range of body sizes than other aircraft types

Small Pilot Candidates:
There is a possibility of assigning candidates much smaller than current requirements to heavy aircraft. The C-21, KC-10, and KC-135 are very accommodating, and would accommodate anyone that fits into training aircraft. These people could be as small as 5 feet tall!

For the remaining heavy aircraft, reach to Rudders is fairly easy (with the exception of the C-141), and the only reaches that could pose a problem are in the C-130 (Inertial reel lock - in very old models, and Fire T- handles). This aircraft requires an arm Span of approximately 64".

Large Pilot Candidates:
With the exception of the C-21 (Maximum sitting Height 39" – Maximum Buttock-Knee length 26.2"), much larger pilots could be assigned to Heavy aircraft. There was so much room in these cockpits that we did not even measure the amount of clearance. Our large subjects could place the seat full up and usually full forward and still had overhead and leg clearance. Anyone who gets through Training aircraft will be accommodated in these Heavy aircraft.

## 11.0 USE OF THE DATA

Software has been written and distributed which accepts input of an individual's anthropometric dimensions and gives output of all aircraft in which that individual is accommodated. In the

event that this document must be used for the same purpose, the procedure is as follows: First small candidates must be measured for Sitting Eye Height, Shoulder Height Sitting (Acromion), Buttock-Knee length, Knee Height Sitting, and Arm Span. First, compare the Sitting Eye Height measurements with the data in Table 3.2. If the candidate's Sitting Eye Height is less than 29.6 inches, this individual will not have adequate external vision in the T-38 or T-1. There would be no follow-on Trainer for this individual to fly. However, given the variability in anthropometric measurements, and the variability due to posture in the cockpit accommodation measurements, those who are close to 29.6 inches for Sitting Eye Height may be classified as marginal and given a "fit-check" in those aircraft. If the Sitting Eye height is greater than 29.6 inches, then it is important to calculate the amount greater and apply the adjustment listed in column three of Table 3.2. If for example, the candidate has a Sitting Eye Height of 30 inches, that value is 2.5 inches greater than the minimum requirement for the T-37. Since that seat adjusts in 0.625-inch notches, the candidate could lower the seat 4 notches and still see the minimum vision requirement. This will place the candidate much closer to rudders and hand controls. However, the candidate is only 0.4 inches larger than the minimum requirement in the T-1. The seat in this aircraft adjusts in 0.8-inch intervals. Therefore the candidate must remain in the full-up seat position for rudder and reach calculations. Those aircraft listed as 1/1 in Table 3.2, are continuously adjustable, so any amount of excess Sitting Eye Height can be subtracted directly from the seat position. At that point, classify the candidate as pass/fail (and possibly marginal) for each aircraft in Table 3.2. Next, using the seat position data, classify the candidate in each aircraft for reach to rudders using Table 4.2. The minimum Comboleg required for reaching full rudders from the full-up seat position is 40.5 inches. However, (using our candidate with a 30-inch Sitting Eye Height as an example) this person could sit 4 notches down, the minimum Comboleg from this position would be 39.5 inches. The last step is to again apply the seat position information, this time to Table 5.3 arm reach to controls. We will assume our candidate pilot has an arm Span of 63 inches and a Shoulder Height of 22 inches. The most restrictive reach requirement in T-37 is full-forward stick with locked harness inertial reels. The equation for calculating miss distance to this control is miss distance = .38603 * Shoulder Height Sitting (22 inches) - .70890 * Arm Span (63 inches) + 34.4 inches. This equals –1.77 inches. A negative miss distance means the candidate went beyond the control by 1.77 inches and is a pass. In addition, since the seat could be lowered 4 notches, the candidate would be 0.28 * 4 = 1.12

inches closer to the control. The final excess reach capability would be -2.89 inches. Once again it must be pointed out that there is variability (called statistical error) in this process and the numbers are best estimates. Those close to the minimum limits could be characterized as marginal and given live fit-tests.

Large pilots must be measured for Sitting Height and Buttock-Knee length (see appendix B for measurement descriptions). Seat effect is irrelevant because the seat will travel up the rails during ejection, and we assume that if a candidate has overhead clearance problems the seat will have been adjusted full-down. Tables 7.2 and 8.1 can be used directly. The same variability caveat applies to large candidates. Those very close to these limits could be classified as marginal and given a fit-check.

## REFERENCES


Gordon, C.C., Churchill, T., Clauser, C.C., Bradtmiller, B., McConville, J.T., Tebbets, I.E., & Walker, R.L. (1989). *1988 Anthropometric Survey of U.S. Army Personnel: Methods and Summary Statistics.* Technical Report NATICK/TR-89/044. Natick, MA: U.S. Army Natick Research and Development Center.

Kennedy, K.W., & Zehner, G.F. (1995). Assessment of Anthropometric Accommodation in Aircraft Cockpits. *SAFE, 25,* (1).

Rogers-Adams, B.M., Andrews, J., & Zehner, G.F. (1998). Anthropometric Accommodation in USAF Training Aircraft: A Comparison of Operational Requirements. *Proceedings of the Thirty-Sixth Annual SAFE Symposium,* pp. 250-257, Phoenix Arizona.

Zehner, G.F. (1996). Anthropometric Accommodation and the JPATS Program. *SAFE, 26,* (3).

Zehner, G.F., Meindl, R.M., & Hudson, J.A. (1992). A *Multivariate Anthropometric Method for Crewstation Design: Abridged* (AL-TR-1992-0164). Wright-Patterson AFB, OH: Crew Systems Directorate, Human Engineering Division, Armstrong Laboratory.

# APPENDIX A. SORTED REACH TO CONTROLS BY AIRCRAFT

This appendix presents tables of controls that were reached to as part of the accommodation assessment for each aircraft. Each control list is sorted according to difficulty in reaching, from the most difficult to the easiest to reach, given the mean of the reach data (either a miss "+" or an excess "-") for the sample of small subjects. The small subject sample size and the relevant anthropometric means are included in the tables. All miss/excess reach data, reported in the tables below, were collected while the subjects strained against a locked restraint system (i.e. Zone 2). For some subjects, an excess reach to a control was not possible to measure because it was simply too close to maintain an extended arm during a strained reach. These controls are listed at the bottom of each table.

**JPATS (T-6): Mean of Misses to Controls Straining Against Locked Restraints**
(Ranked from Greatest to Least Miss Distance)
**Anthropometric Means (N=19) Acromion Height=21.5", Biacromial Breadth=14.3", Span=59.7"**

| Control-FWD Cockpit | Mean (in.) | Control-AFT Cockpit | Mean (in.) |
|---|---|---|---|
| Aux Battery | 6.1 | ADI Backup | 4.3 |
| ADI Backup | 4.5 | Trim Disconnect | 3.9 |
| Downlock Release | 4.2 | Gear Handle | 3.4 |
| Gear Handle | 4.0 | Master GEN | 3.4 |
| Trim Disconnect | 4.0 | Stick Forward Left | 2.9 |
| Generator Switch | 3.8 | Nav Volume | 2.8 |
| Stick Forward Left | 3.7 | Altimeter | 2.1 |
| Park Brake | 3.3 | NACWS Push | 1.3 |
| Nav Volume | 3.1 | Chronometer Select | 0.9 |
| Altimeter | 2.1 | Stick Forward Neutral | 0.2 |
| Emer Gear T-Handle | 1.9 | Flaps | 0.0 |
| Stick Forward Neutral | 1.1 | Stick Neutral Left | -0.3 |
| Chronometer Select | 1.0 | Stick Forward Right | -0.7 |
| Pressurization | 0.8 | Max Throttle | -2.0 |
| Flaps | 0.3 | Master Caution | -3.2 |
| Stick Forward Right | 0.2 | Stick Neutral | -3.8 |
| Stick Neutral Left | -0.2 | | |
| Firewall Shutoff | -1.1 | | |
| Max Throttle | -1.6 | | |
| Stick Neutral | -3.1 | | |
| Master Caution | -3.3 | | |

**Controls were too close or excess measurements (-) not possible due to placement, resulting in reduced sample size**

| | |
|---|---|
| Oxy Supply | Oxy Supply |
| Canopy Fracture | Canopy Fracture |
| Air Control | ENG SYS DIS |

**T-37: Mean of Misses to Controls Straining Against Locked Restraints**

(Ranked from Greatest to Least Miss Distance)

**Anthropometric Means (N=21) Acromion Height=21.6", Span=61.5"**

| **Control-Left Seat** | **Mean (in.)** | **Control-Right Seat** | **Mean (in.)** |
|---|---|---|---|
| Cockpit Air Lever | 7.2 | Canopy Jettison-T | 10.7 |
| Emergency Gear T-Handle | 2.5 | Left Ignition Switch | 8.3 |
| Oxygen Emergency Lever | 1.5 | Right Starter Switch | 5.1 |
| Left Ignition Switch | 1.3 | Cockpit Air Lever | 2.3 |
| Right Generator Switch | 1.3 | Right Generator Switch | 2.3 |
| Stick Full Forward Left | 1.0 | Fuel Shutoff-T | 1.3 |
| Fuel System Switch | 0.8 | Stick Full Forward Left | 1.1 |
| Right Starter Switch | 0.7 | Oxygen Supply Lever | 0.9 |
| Land Gear Override | 0.5 | Land Gear Override | 0.0 |
| Ejection Grip | 0.1 | Fuel System Switch | -0.1 |
| Land Gear Handle | 0.1 | Land Gear Handle | -0.5 |
| Fast Slave Switch | -1.1 | Stick Full Forward | -1.1 |
| Stick Full Forward | -1.1 | Trim CB | -1.6 |
| Right Fuel Shutoff-T | -1.2 | Throttles | -2.5 |
| Throttles Retard | -2.2 | Stick Neutral | -4.2 |
| Stick Neutral | -4.0 | Flaps | -6.4 |
| Flaps | -6.5 | | |

**T-1: Mean of Misses to Controls Straining Against Locked Restraints**
(Ranked from Greatest to Least Miss Distance)
**Anthropometric Means (N=23) Acromion Height=21.5", Biacromial Breadth=13.6", Span=61.4"**

| Control-Copilot | Mean (in.) | Control-Pilot | Mean (in.) |
|---|---|---|---|
| HDG SW (Pilot side) | 2.5 | Gear Handle | 1.2 |
| Oxygen Sys Ready | 1.2 | Parking Brake | -1.1 |
| AHRS Bat Test | 0.4 | EADI | -1.7 |
| Bleed Air Sel Switch | 0.1 | H Stabilator De Ice | -1.7 |
| Engine EFC | -0.1 | RAD ALT | -2.1 |
| ADI | -0.3 | Flaps | -2.2 |
| Engine Sync Switch | -0.7 | Fuel X-Feed | -2.7 |
| Paging Volume Switch | -0.8 | Hyd Press Rel | -3.6 |
| CRS SW | -1.0 | Throttle | -4.8 |
| Air Data Display Dim | -1.3 | Engine Start | -5.6 |
| Throttle | -1.8 | | |
| Paging Volume Switch | -2.0 | | |
| Flaps | -2.8 | | |
| Speed Brake Switch | -3.0 | | |
| Gear Handle | -3.5 | | |
| Ignition | -4.3 | | |
| Battery Switch | -4.4 | | |
| Yaw Damper Switch | -6.3 | | |
| Engine Fire | -6.7 | | |
| Master Caution | -9.3 | | |

**T-38: Mean of Misses to Controls Straining Against Locked Restraints**
(Ranked from Greatest to Least Miss Distance)
**Anthropometric Means (N=18) Acromion Height=21.6", Biacromial Breadth=14.1", Span=62.6"**

| Control-Forward Cockpit | Mean (in.) | Control-Aft Cockpit | Mean (in.) |
|---|---|---|---|
| NAV Volume | 6.2 | NAV Volume | 6.1 |
| Fuel Shut-Off Switch | 5.7 | Oxygen Supply Switch | 5.3 |
| Oxygen Supply Switch | 5.2 | Engine Start | 4.8 |
| Engine Start | 5.0 | UHF Ctr. Knob | 4.6 |
| UHF Ctr. Knob | 4.9 | Stick Full Forward and Left | 3.3 |
| Right Generator Switch | 4.6 | Canopy Jettison T-Handle | 3.2 |
| Stick Full Forward and Left | 3.6 | AOA Index Dimmer | 2.9 |
| Canopy Jettison T-Handle | 3.5 | Lighting Panel - Floods | 2.6 |
| AIMS Control Master Switch | 3.1 | ADI Pitch Trim Knob | 2.3 |
| AOA Index Dimmer | 2.8 | HSI Course Set | 2.2 |
| Pitot Heat Switch | 2.7 | NAV Mode Switch | 2.0 |
| Emerg. Gear T-Handle | 2.7 | Comm-NAV Override Switch | 1.9 |
| Radio Transfer Switch | 2.6 | Downlock Override Button | 1.1 |
| Boost Pump Switch | 2.5 | Throttle - Max | 1.1 |
| ADI Pitch Trim Knob | 2.1 | Stick Full Forward | 1.0 |
| HSI Course Set | 2.1 | Master Caution | 0.8 |
| NAV Mode Switch | 1.9 | Landing Gear Handle | -0.3 |
| Stick Full Forward | 1.9 | Inertia Reel Lock | -0.4 |
| Throttle - Max | 1.3 | Stick Neutral Left | -0.7 |
| Master Caution | 1.1 | | |
| Downlock Override Button | 0.9 | | |
| Inertia Reel Lock | 0.2 | | |
| Stick Neutral Left | 0.0 | | |
| Lighting Panel - Floods | 0.0 | | |
| Landing Gear Handle | -0.2 | | |

**Controls were too close or excesss measurements (-) not possible due to placement, resulting in reduced sample size**

| Forward Cockpit | Aft Cockpit |
|---|---|
| Wing Flap Lever | Wing Flap Lever |
| Ejection Grips | Ejection Grips |
| Ignition Inverter | STAB AUG |
| AUX FLAPS | AUX FLAPS |
| Yaw Damp | |
| Lighting Panel - Floods | |

**A-10: Mean of Misses to Controls Straining Against Locked Restraints**
(Ranked from Greatest to Least Miss Distance)
**Anthropometric Means (N=15) Acromion Height=21.0", Span=62.7"**

| Control | Mean (in.) |
|---|---|
| Fuel Quantity Indicator | 4.5 |
| Slant Range Switch | 2.4 |
| Canopy Jettison Switch | 2.0 |
| Caution Light | 1.7 |
| Fuel System Open/Close | 1.5 |
| Landing Gear Handle | 0.6 |
| Emergency Brake Handle | 0.4 |
| ADI Right Switch | 0.4 |
| External Stores Jettison Switch | 0.1 |
| Master Caution | -0.1 |
| Oxygen Switch | -0.8 |
| Stick Full Forward and Left | -0.9 |
| Optics Sight Middle Switch | -2.0 |
| Stick Full Forward | -2.3 |
| Left Fire Pull | -2.9 |
| Stick Full Forward and Right | -2.9 |
| Right Fire Pull | -3.2 |
| Throttle-Max | -3.5 |
| Ejection Handles | -7.1 |

**F-117: Mean of Misses to Controls Straining Against Locked Restraints**
(Ranked from Greatest to Least Miss Distance)
**Anthropometric Means (N=17) Acromion Height=21.3", Span=61.5"**

| Control | Mean (in.) |
|---|---|
| AHRS Fast Erect PNL | 5.3 |
| UHF Radio Control Vol | 5.0 |
| RUHF Radio Control Vol | 4.7 |
| Landing Gear | 3.2 |
| Fuel Quantity Sel Switch | 3.1 |
| Arament Door Arm Jettison | 2.7 |
| Emer Gear T- Handle | 2.3 |
| OXY REG ON/OFF | 1.4 |
| Drag Shut T-Handle | 1.1 |
| APU Fuel SW | 0.9 |
| Emerg. Refuel T-Handle | 0.8 |
| Fire Push On | -0.3 |
| Fuel System Dump | -0.8 |
| Control Stick Full Forward/Left | -1.2 |
| Control Stick Full Forward | -1.9 |
| Control Stick Full Forward/Right | -2.7 |
| Stick Neutral and Left | -3.0 |
| Control Stick Neutral | -3.2 |
| MAX Throttle | -3.5 |
| Ejection Handles | -5.8 |

**Controls were too close or excesss measurements (-) not possible due to placement, resulting in reduced sample size**

Rt CB Panel - Flood Light
DEF Turn Switch
AMAD/EPU Left GCP
Zerioze Switch
Pitot Heat Switch
Weapns Interface UNLOCK
Grn Cont Door Switch
Canopy Jet T-Handle

**F-15C&D: Mean of Misses to Controls Straining Against Locked Restraints**
(Ranked from Greatest to Least Miss Distance)
**Anthropometric Means (N=30) Acromion Height=21.6", Biacromial Breadth=14.1", Span=62.6"**

| F-15C and F-15D Control-Forward Cockpit | Mean (in.) | F-15D (N=6) Control-Aft Cockpit | Mean (in.) |
|---|---|---|---|
| Fuel QTY Select | 5.2 | Altimeter | 3.8 |
| Pitot Heat | 4.7 | ILS Volume | 3.6 |
| Jettison Select | 4.4 | Ejection Mode T-Handle | 3.3 |
| TEWS Int Knob | 4.3 | EMERG Land Gear | 2.2 |
| EMERG Vent Handle | 4.0 | Oxygen Regulator | 2.1 |
| EMERG Land Gear | 3.9 | STICK Forward and Left | 1.9 |
| JFS Handle | 3.9 | Storm Flood Knob | 0.9 |
| Land Gear Handle | 3.4 | EMERG Brake Steer Hand | 0.8 |
| Oxygen Supply | 3.0 | Comm Switch | 0.5 |
| Inlet Ramp Switch | 2.8 | STICK Netural and Left | 0.0 |
| STICK Forward and Left | 2.7 | STICK Full Forward | -0.5 |
| Air Source | 2.6 | Master Caution | -1.4 |
| EMERG Brake Steer Handle | 2.4 | L ENG Fire Warn Light | -1.6 |
| Stores Jettison | 1.4 | Radio Mode Select | -1.9 |
| STICK Full Forward | 0.9 | Canopy Emerg Jettison | -2.8 |
| Fuel Dump Switch | 0.5 | Throttle Max | -3.6 |
| AMAD | 0.0 | Canopy Latch | -4.5 |
| STICK Netural and Left | 0.0 | Ejection Grip | -5.9 |
| Armament Safety Switch | -0.2 | | |
| Canopy Emerg Jett | -0.5 | | |
| Storm Flood Ctrl | -0.6 | | |
| Canopy Latch | -0.8 | | |
| Radar Mode Select | -0.8 | | |
| Emergency A/R | -1.5 | | |
| ENG Start Fuel Switch | -1.8 | | |
| Throttle Max | -1.8 | | |
| Avionics Select | -2.1 | | |
| Ejection Grip | -4.1 | | |

**Controls were too close or excesss measurements (-) not possible due to placement, resulting in reduced sample size**

| | |
|---|---|
| Radio Mode Select | Inertia Reel Lock |
| Inertia Reel Lock | |

**F-15E: Mean of Misses to Controls Straining Against Locked Restraints**
(Ranked from Greatest to Least Miss Distance)
**Anthropometric Means (N=14) Acromion Height=21.2", Span=62.2"**

| **Control-Forward Cockpit** | **Mean (in.)** | **Control-Aft Cockpit** | **Mean (in.)** |
|---|---|---|---|
| Jettison Select | 5.7 | Nuclear Consent | 5.7 |
| Nuclear Consent | 5.6 | Emergency Landing Gear | 4.5 |
| Fuel Quantity Select | 5.5 | Throttle Max | 2.7 |
| Land Gear Handle | 4.3 | Ejection Mode T | 2.5 |
| Fuel Dump Switch | 3.7 | STICK Forward and Left | 2.4 |
| Oxygen Supply | 2.3 | Master Caution | 1.1 |
| STICK Forward and Left | 2.3 | STICK Netural and Left | 0.6 |
| Armament Safety Switch | 2.3 | STICK Full Forward | 0.3 |
| Stores Jettison | 2.0 | Canopy Jettison | -0.4 |
| Master Caution | 1.7 | Oxy Regulator | -0.8 |
| STICK Full Forward | 0.9 | Joy Stick Left | -1.5 |
| Canopy Emerg Jettison | 0.6 | Anti G Test | -1.8 |
| STICK Netural and Left | 0.4 | Joy Stick Right | -2.1 |
| AMAD | 0.4 | | |
| Throttle Max | -1.2 | | |

**F-16C&D: Mean of Misses to Controls Straining Against Locked Restraints**
(Ranked from Greatest to Least Miss Distance)
**Anthropometric Means (N=22) Acromion Height=21.8", Span=61.5"**

| **F-16C and F-16D Control-Forward Cockpit** | **Mean (in.)** | **F-16D (N=5) Control-Aft Cockpit** | **Mean (in.)** |
|---|---|---|---|
| Threat Warn Int Knob | 5.6 | Altimeter | 3.3 |
| Right MFD Bright | 4.5 | Threat Warn Int Knob | 3.3 |
| Left MFD Contrast | 4.3 | Alt Flaps Switch | 2.7 |
| Altimeter | 3.2 | Ejection Mode Select | 2.3 |
| Master Arm Switch | 2.7 | HSI Heading | 1.6 |
| HSI Heading | 1.7 | Stores Jettison Button | 1.4 |
| Stores Jettison Button | 1.1 | Hook Switch | 0.8 |
| Hook Switch | 0.7 | Downlock Release Button | 0.0 |
| Man Pitch Override Switch | 0.0 | Max Throttle | -0.5 |
| Downlock Release Button | 0.0 | Nose Wheel Steering | -1.0 |
| Max Throttle | -0.1 | Canopy Jettison T-Handle | -1.2 |
| Fire Detect Button | -0.9 | Man Pitch Override Switch | -1.4 |
| Air Source Knob | -1.3 | Landing Gear Handle | -1.5 |
| Eng Fire | -1.4 | Oxygen 100% 1 | -2.6 |
| Main PWR Switch | -1.5 | Master Caution | -3.1 |
| Landing Gear Handle | -1.5 | Eng Fire | -3.9 |
| Master Caution | -1.6 | Flight Control Stick | -4.4 |
| Alt Flaps Switch | -1.8 | Harness Release | -6.0 |
| Canopy Jettison T-Handle | -1.8 | Ejection Handles | -6.3 |
| Master Zeroize Switch | -2.6 | | |
| Oxygen 100% | -2.7 | | |
| Flight Control Stick | -4.0 | | |
| Harness Release | -7.5 | | |
| Ejection Handles | -7.9 | | |

**F-22: Mean of Misses to Controls Straining Against Locked Restraints**
(Ranked from Greatest to Least Miss Distance)
**Anthropometric Means (N=13) Acromion Height=21.2", Span=63.6"**

| Control | Mean (in.) |
|---|---|
| Gear Overrider | -0.1 |
| Battery | -0.2 |
| Stores Jettison | -0.3 |
| Landing Gear | -0.3 |
| Master Arm | -0.7 |
| Tanks Switch | -0.9 |
| Formation Light Control | -2.0 |
| AAR Switch | -3.5 |
| Throttles- Max | -4.0 |
| Stick Full Forward | -4.2 |
| Seat Adjust Switch | -5.9 |
| UNDO Switch - ICP | -6.7 |
| Dedicated Annunciators | -6.9 |

**Controls were too close or excesss measurements (-) not possible due to placement, resulting in reduced sample size**

Zeroize
Engine Panel
FLCS
Map Case

**B-1B: Mean of Misses to Controls Straining Against Locked Restraints**

(Ranked from Greatest to Least Miss Distance)

**Anthropometric Means (N=17) Acromion Height=21.2", Span=62.1"**

| Control | Mean (in.) |
|---|---|
| Stick Disconnect Handle | 4.8 |
| Cabin Air Dump T | 3.1 |
| Radar Altimeter Select | 2.6 |
| Aft Safe External Tank Jettison | 1.8 |
| PA Release | 1.4 |
| Stick Full Forward and Left | 1.4 |
| Clock | 1.3 |
| Hatch Jettison T | 0.6 |
| Stick Full Forward | 0.0 |
| Prep Eject Button | -1.3 |
| Throttles-Max | -2.2 |
| Ground Safe | -2.9 |
| Stick Neutral and Left | -2.9 |
| Landing Lights | -3.9 |
| Wing Sweep Lever | -4.4 |

**Controls were too close or excesss measurements (-) not possible due to placement, resulting in reduced sample size**

Oxygen Lever
Fire DETR Panel Switch
Ejection Mode Select
Trim Standby Switch

**B-2: Mean of Misses to Controls Straining Against Locked Restraints**
(Ranked from Greatest to Least Miss Distance)
**Anthropometric Means (N=14) Acromion Height=21.2", Span=61.9"**

| **Control-Left Cockpit** | **Mean (in.)** | **Control-Right Cockpit** | **Mean (in.)** |
|---|---|---|---|
| Emergency Landing Gear Reset | 5.7 | Fuel Pull Toggle | 9.0 |
| Jettison Switch EXEC | 1.8 | Flight Data BRT | 3.3 |
| Flight Data Course Select | 1.5 | Ejection Sequence Select | 3.3 |
| Backup Oxygen Select | 1.3 | Emergency Landing Gear Reset | 1.2 |
| Vertical Velocity Indicator | 0.8 | Weapon Release | -0.6 |
| Entry Hatch Close | 0.0 | Data Entry BRT | -2.2 |
| Stick Full Forward | -0.1 | Throttles-Max | -2.5 |
| Landing Gear Handle | -0.3 | GPS Top Switch | -3.1 |
| PA Enable Consent Switch | -0.4 | Cursor Stick | -3.6 |
| Fire Warning Right APU | -1.3 | Master Caution | -7.6 |
| Right APU Stop | -1.3 | | |
| PIN Storage Latch | -1.5 | | |
| Hatch Jettison T | -1.6 | | |
| Throttle-Max | -2.3 | | |
| Right Ejection Grip (middle) | -7.0 | | |
| Master Caution | -7.1 | | |

**B-52H: Mean of Misses to Controls Straining Against Locked Restraints**

(Ranked from Greatest to Least Miss Distance)

**Anthropometric Means (N=19) Acromion Height=21.1", Span=62.6"**

| **Control-Left Cockpit** | **Mean (in.)** | **Control-Right Cockpit** | **Mean (in.)** |
|---|---|---|---|
| #8 Fire Shutoff Switch | 9.2 | #1 Fire Shutoff Switch | 10.43684 |
| Control Column Disconnect | 8.1 | Land Gear Handle | 3.384211 |
| Landing Gear | 5.4 | Throttles-Max | -0.14737 |
| G-Meter Reset | 5.3 | | |
| Engine Fire Detect Select Switch | 5.2 | | |
| EVS Monitor C Contrast (Left Hand) | 4.6 | | |
| Hydraulics Rudder/Elevator Right Toggle | 4.3 | | |
| EVS Monitor C Contrast (Right Hand) | 4.3 | | |
| EVS Mode Select Switch | 4.1 | | |
| Bomb Doors Switch | 3.0 | | |
| Pylon Jettison Consent (Right Hand) | 1.5 | | |
| GAM-72 Jettison | 1.3 | | |
| Yoke Full Forward | 0.8 | | |
| Pylon Jettison Consent (Left Hand) | -0.6 | | |
| Emergency Alarm Switch | -1.0 | | |
| #8 Throttle-Max | -1.2 | | |
| Wing Flap Lever | -1.5 | | |
| B/Y CB Warning | -1.5 | | |
| Munitions Consent-Lock | -3.3 | | |
| Jettison Control Switch | -3.5 | | |

**Controls were too close or excesss measurements (-) not possible due to placement, resulting in reduced sample size**

Lateral Trim Cutout

CB Window Heat

Oxygen Supply On

**C-130: Mean of Misses to Controls Straining Against Locked Restraints**
(Ranked from Greatest to Least Miss Distance)
**Anthropometric Means (N=17) Acromion Height=21.6", Biacromial Breadth=14.2", Span=62.6"**

| Control-Left Cockpit | Mean (in.) | Control-Right Cockpit | Mean (in.) |
|---|---|---|---|
| Flight Deck Dome | 5.2 | Gen Disc #1 | 5.8 |
| Fire Ext #4 | 4.5 | Fire Ext #1 | 4.9 |
| RH Wing Isolation | 3.2 | Side Panel Lights | 4.7 |
| Pilot Integrated Disp Fwd Lt | 2.8 | Flaps/Jump Light (same time) | 3.2 |
| Feather #4 | 2.2 | Brake Select | 2.5 |
| Air Diverter | 1.9 | Air Diverter | 1.6 |
| NAV SEL Knob | 1.8 | Copilot Intercom | 1.6 |
| Elec Fuel Corr #4 | 1.5 | NAV SEL Knob | 1.0 |
| ADI Up Rt | 0.9 | #1 Throttle Max | 0.9 |
| Inertia Reel | 0.5 | Gear Handle | 0.8 |
| Preset Grd Aft Rt | 0.0 | Prop Feather Over Ride #4 | 0.2 |
| Gen Disc #4 | -0.3 | Gen Disc #4 | -1.2 |
| #4 Throttle Max | -1.9 | Feather #1 | -1.5 |
| Nose Wheel Steering | -2.1 | Paratroop Alarm Bell | -2.4 |
| Flaps | -2.2 | Flaps | -2.5 |
| SKE Zone Marker SEL | -2.4 | #2 ADF Aft Rt | -3.4 |
| Paratroop Alarm | -2.5 | OXY Supply | -4.5 |
| EM Depressure | -2.8 | Fire Ext #4 | -4.6 |
| Starter #1 | -2.8 | | |
| Mag Compass Up Lt | -3.3 | | |
| Mst Vol Ctrl Aft Lt | -3.4 | | |
| OXY Emergency | -3.7 | | |
| Deflectors O-O-C | -3.8 | | |
| Gen Disc #1 | -3.9 | | |
| SKE Repeat on GS | -5.2 | | |

**Controls were too close or excesss measurements (-) not possible due to placement, resulting in reduced sample size**

Trim-Yaw SW

**C-141: Mean of Misses to Controls Straining Against Locked Restraints**

(Ranked from Greatest to Least Miss Distance)

**Anthropometric Means (N=17) Acromion Height=21.5", Biacromial Breadth=13.6", Span=61.3"**

| Control-Left Cockpit | Mean (in.) | Control-Right Cockpit | Mean (in.) |
|---|---|---|---|
| Circuit Breaker - Cargo | 13.3 | Pilot Console Lights | 9.1 |
| Co-Pilot's Lights | 10.6 | Starter #1 | 8.3 |
| Landing Gear | 9.5 | Auto Pilot Turn | 4.6 |
| Engine #4 Fire Test | 8.6 | Fire Extinguisher #1 | 3.6 |
| CoPilot ADF Control TRF | 7.4 | Spoiler Auto Release | 2.5 |
| Thrust Limiter | 5.6 | Chute Release Emg | 2.4 |
| Yaw Damper Test Button | 5.1 | Starter #4 | 2.3 |
| Rudder Pressure Over | 4.2 | IFF | 1.5 |
| Emer Cabin Depress | 2.7 | Gear Up Warning | 1.5 |
| Fire Extinguisher #4 | 2.5 | Landing Gear Handle | 1.0 |
| Chute Release | 2.2 | Emer Cabin Depress | 0.8 |
| Weather Radar Slew | 2.2 | Oxygen Supply On/Off | 0.4 |
| ADI | 1.6 | Clock Push | 0.0 |
| Cargo Doors ALL | 1.4 | Airspeed Mach Ind | -0.3 |
| Compass Set Index | 1.2 | Engine Fire Test #4 | -0.8 |
| Push To Caution | 0.9 | Aileron Trim | -1.7 |
| Brake T-Handle | 0.7 | Copilot Stall Prevention Sys | -1.9 |
| INST Power Toggle | 0.1 | Vertical Scale IAS | -2.1 |
| Pilot ADF Volume | -0.1 | Fire Extinguisher #4 | -2.6 |
| Interphone (Lg. Knob) | -0.5 | Rudder Trim | -2.6 |
| BDHI VOR 2 | -0.6 | Yaw Damper | -2.6 |
| Flaps | -0.6 | Bailout Alarm | -2.6 |
| Mach Slew lever | -1.0 | Throttle MAX | -4.7 |
| Oxygen Regulator - EM Flow | -1.3 | Copilot Nav Sel Pnl INSI | -4.8 |
| Stall Prevention Panel - Test | -1.5 | Rudder HI Pres OVR | -6.6 |
| Aileron SW | -1.7 | | |
| Bailout Alarm | -2.2 | | |
| Nosewheel Steering | -2.2 | | |
| Rudder Trim | -2.5 | | |
| Stall Prevention System | -2.6 | | |
| Starter #4 | -3.1 | | |
| Fire Extinguisher #1 | -3.5 | | |
| Pilot's Nav Sel Pnl | -4.4 | | |
| Throttles MAX | -5.4 | | |

**Controls were too close or excesss measurements (-) not possible due to placement, resulting in reduced sample size**

| Left Cockpit | Right Cockpit |
|---|---|
| Inertial Reel Lock | Copilot Console Lights |
| Pilot's Lights | |
| Starter #1 | |

**C-17: Mean of Misses to Controls Straining Against Locked Restraints**
(Ranked from Greatest to Least Miss Distance)
**Anthropometric Means (N=18) Acromion Height=21.3", Biacromial Breadth=14.0", Span=61.1"**

| Control-Left Cockpit | Mean (in.) | Control-Right Cockpit | Mean (in.) |
|---|---|---|---|
| Door Ramp Open | 8.2 | MFD Contrast | 3.3 |
| MFD SYM | 3.2 | Wing Vents Inert | 2.4 |
| Fire Detect #1 | 1.4 | Fire Detect #1 | 2.2 |
| Depressurization | 0.0 | Oxygen Crossfeed | 0.9 |
| Hydraulic RAT | -0.1 | Digit | 0.9 |
| Fire #4 | -0.7 | Depressurization | 0.3 |
| VOR TAC ADF | -0.8 | VOR TAC ADF | -0.7 |
| MFD Contrast | -0.9 | Fire #1 | -0.9 |
| Digit | -1.6 | Landing Lights Left Wing | -1.7 |
| MFD Bright | -1.6 | Landing Gear | -3.8 |
| Trim Select | -2.5 | Nose Wheel Steering | -4.5 |
| ADI Pull-to-cage | -2.8 | Throttles-Max | -5.0 |
| OXY Emergency Select | -2.9 | | |
| Inertia Reel Lock | -4.6 | | |
| Nose wheel steering | -4.7 | | |
| Landing Lights R wing | -4.7 | | |
| Slats Full Forward | -4.8 | | |
| Throttles-Max | -5.3 | | |
| Fire #1 | -6.9 | | |

**Controls were too close or excesss measurements (-) not possible due to placement, resulting in reduced sample size**

| | |
|---|---|
| Instrument Lights - Panel | Remote Dispense |
| FED Arm | Oxygen Supply |
| Remote Dispense | Hydraulic RAT |
| APU OFF/ARM | Bailout Alarm |
| | Slats Full Forward |
| | Fire #4 |

**C-5: Mean of Misses to Controls Straining Against Locked Restraints**
(Ranked from Greatest to Least Miss Distance)
**Anthropometric Means (N=21) Acromion Height=21.4", Biacromial Breadth=14.1", Span=61.9"**

| Control-Left Cockpit | Mean (in.) | Control-Right Cockpit | Mean (in.) |
|---|---|---|---|
| Inst. Switch - Guarded | 5.8 | INS No. 2 CDU Knob | 7.9 |
| Fire Handle #4 | 3.6 | Alt. Trim Select Knob | 4.6 |
| Center Console Light Switch | 2.8 | Fire Handle #1 | 3.8 |
| Weather Radar Control Switch | 2.6 | Center Console Lite Switch | 3.2 |
| Flap Lever | 2.2 | Pilot MultiMode Radar | 1.9 |
| Radar Mode Knob | 1.9 | Slat Drive Disconnect Switch | 1.4 |
| INS #3 Switch | 1.8 | Stall Limiter Switch | 1.4 |
| Spoiler Switch | 1.1 | IFF Code Sel Knob | -0.4 |
| Aileron Trim Knob | -0.1 | Wheel Spin Det Test Switch | -0.7 |
| Nose Wheel Steering | -1.1 | Indicator Lights | -1.1 |
| Instrument Power Switch | -1.1 | Flap Handle | -1.3 |
| Stall Limiter Warning Switch | -1.2 | Landing Gear Lever | -1.7 |
| Nav. Mode Select Knob | -1.2 | Oxygen Reg Supply Switch | -2.5 |
| TACAN Select Knob | -1.4 | Fire Handle #4 | -3.0 |
| RAT Switch | -1.6 | Throttles #1and #2 | -3.8 |
| Oxy Flow Switch | -2.4 | | |
| Fire Handle #1 | -2.6 | | |
| Throttles #3 and #4 | -3.7 | | |
| Yoke | -3.9 | | |
| Outboard Elevator LS | -4.1 | | |

**Controls were too close or excesss measurements (-) not possible due to placement, resulting in reduced sample size**

| | |
|---|---|
| Horizontal Situation Indicator | HSI CSE Set Knob |
| Starter Button #1 | Copilot Panel Light Select Switch |
| | Copilot Windshield Wipe Select Switch |

**KC-135: Mean of Misses to Controls Straining Against Locked Restraints**
(Ranked from Greatest to Least Miss Distance)
**Anthropometric Means (N=20) Acromion Height=21.2", Biacromial Breadth=14.0", Span=61.5"**

| Control-Left Cockpit | Mean (in.) | Control-Right Cockpit | Mean (in.) |
|---|---|---|---|
| Upper Strobe Lt | 12.5 | Cross Over Valve | 6.7 |
| Land Lights Switch | 7.6 | Upper Strobe Lt | 4.5 |
| Cross Over Valve | 5.9 | Aileron Trim | 4.3 |
| Land Gear Handle | 3.9 | LR Radio Alt Reset | 2.4 |
| Aileron Trim | 3.6 | Rudder Trim | 1.6 |
| Altimeter Reset | 3.1 | Altimeter Reset | 0.6 |
| ADI Test Knob | 2.3 | Throttles Max | 0.4 |
| Battery PWR Switch | 2.0 | Emerg. Start GEN | 0.2 |
| Press. Emergency Rel. T | 1.9 | Fire T #1 | -0.6 |
| Instrument Gyro | 1.9 | Flap Lever | -2.8 |
| Yaw Damp Test | 0.7 | Land Gear Handle | -4.3 |
| Throttles Max | 0.3 | Auto Alt Hold | -4.8 |
| Rudder Trim | 0.3 | Fire T #4 | -5.2 |
| Flap Lever | -0.5 | STAB Cutout Switch | -5.5 |
| #4 Eng Fire | -1.3 | | |
| NWS Wheel | -2.1 | | |
| Stab Trim Cutout | -3.9 | | |
| Auto Alt Hold | -4.8 | | |
| #1 Eng Fire | -5.1 | | |

**Controls were too close or excesss measurements (-) not possible due to placement, resulting in reduced sample size**

| | |
|---|---|
| Fuel Dump | Volume Knob |
| AUX Listen Switch | Window Heat |
| Hydraulic Pump Rt | |

**UH-1: Mean of Misses to Controls Straining Against Locked Restraints**
(Ranked from Greatest to Least Miss Distance)
**Anthropometric Means (N=19) Acromion Height=21.1", Biacromial Breadth=14.3"; Span=61.6"**

| Control | Mean (in.) |
|---|---|
| Fire T #2 | 10.2 |
| Rotor Brake | 8.3 |
| Fire T #1 | 6.0 |
| Store Jett Handle | 4.3 |
| GPS Zero | 4.0 |
| Radar Altimeter | 1.2 |
| Collective | 1.1 |
| Cut Cable | 0.0 |
| Cyclic Forward | -0.2 |
| PAX Alarm | -2.2 |

**MH-60: Mean of Misses to Controls Straining Against Locked Restraints**
(Ranked from Greatest to Least Miss Distance)
**Anthropometric Means (N=17) Acromion Height=21.1", Biacromial Breadth=14.3"; Span=61.5"**

| Control | Mean (in.) |
|---|---|
| Eng Fire T #2 | -0.4 |
| Throttle Maximum | -0.4 |
| HDD Knob | -1.1 |
| ASPD Collective Adjustment | -2.1 |
| Cyclic Full Forward | -2.6 |
| APU T Handle | -2.6 |
| Fire Ext Switch | -2.8 |
| Fuel Dump | -3.8 |
| Eng Fire T #1 | -4.5 |
| Master Caution | -8.5 |

**MH-53J: Mean of Misses to Controls Straining Against Locked Restraints**
(Ranked from Greatest to Least Miss Distance)
**Anthropometric Means (N=20) Acromion Height=21.2", Biacromial Breadth=14.3"; Span=61.7"**

| Control | Mean (in.) |
|---|---|
| YAW/ALT AFCS | 6.3 |
| Weapons Arm Switch | 4.4 |
| #2 Emerg T | 4.0 |
| Collective | 3.0 |
| Radar Cursor | 3.0 |
| External Cargo Hook | 1.5 |
| Cargo Release T Handle | 1.4 |
| Cyclic Forward | 1.0 |
| #1 Emerg T | -0.2 |
| Fire Ext Switch Main | -1.0 |
| Master Caution | -4.2 |

## APPENDIX B. ANTHROPOMETRIC MEASUREMENT DESCRIPTIONS

| Measurement | Description |
|---|---|
| Abdominal Depth | The horizontal distance between the point of maximum protrusion on the abdomen and the same level on the back. The subject stands erect with the arms hanging relaxed at the sides. |
| Buttock-Knee Length | The horizontal distance between the most protrusive point of the right buttock and the most forward point of the right knee. The subject sits on a flat surface, looking straight ahead. The thighs are parallel and the feet are in line with the thighs on a surface adjusted so the knees are bent 90 degrees. |
| Shoulder Breadth (Biacromial) | The horizontal distance between the right and left acromion landmarks at the tips of the shoulders.The subject sits or stands erect, with the upper arms relaxed and the forearms and hands extended forward with the palms facing each other. |
| Shoulder Breadth (Bideltoid) | The horizontal distance across the maximum lateral protrusions of the right and left deltoid muscles. |
| Sitting Eye Height | The vertical distance between the sitting surface and the outer corner of the right eye. The subject sits erect on a flat surface with the head oriented in the Frankfurt Plane. |
| Sitting Height | The vertical distance between the sitting surface and the top of the head. The subject sits erect on a flat surface with the head in the Frankfurt plane. |

| Measurement | Description |
|---|---|
| Sitting Knee Height | The vertical distance between the foot rest and the top of the right patella. The subject sits erect on a flat surface. The thighs are parallel and the feet are in line with the thighs on a surface adjusted so the knees are bent 90 degrees. |
| Sitting Shoulder (Acromial) Height | The vertical distance between the sitting surface and the tip of the right shoulder. The subject sits erect on a flat surface looking straight ahead. The upper arms are relaxed at the sides with the forearms and hands extended horizontally with the palms facing each other. |
| Span | The distance between the tips of the middle fingers of the horizontally outstretched arms. The subject stands erect with the heels together. Both arms and hands are stretched horizontally with the tip of the middle finger of one hand just touching a side wall. The technician measures from the wall to the tip of the opposite finger. |
| Stature | The vertical distance between the standing surface and the top of the head. The subject stands erect with the heels 10 cm apart and the head in the Frankfurt plane. The arms are relaxed at the sides and the weight is distributed equally on both feet. |
| Thigh Circumference | The maximum circumference of the upper thigh. |
| Weight | The weight of the subject as the subject stands on the scale, clad in lightweight garments with the weight distributed equally on both feet. |

# APPENDIX C: AIRCRAFT FUNCTIONAL ANTHROPOMETRIC REQUIREMENTS

## A/OA-10 Body Size/Reach Requirements

### Measurement Assumptions

Body measurements are to be taken with full combat, adverse weather gear as well as in chemical warfare ensemble. G-Suit should be inflated.

### Vision Requirement

Pilots must be able to sit at the design eye point while at the same time being able to manipulate the flight controls (stick, pedals, brakes, throttles) through the full range of motion. Pilots must also be able to see the aim point on the runway during all types of normal and emergency approaches (no-flap and single-engine).

### Body Clearances/Size Requirements

- The pilot's helmet should not hit the canopy during tactical maneuvers; there should be no interference with head movements.
- The pilot's shins should not come in contact with the main instrument panel.
- The pilot should have full stick clearance with thighs so that the full range of stick motion is available with G-Suit inflated.
- The pilot should not come into contact with any aircraft structure on ejection or be restricted by an aircraft structure upon ground egress.
- The pilot's weight must meet ejection seat envelope requirements (ACES II naked body weight envelope is 140 to 211 pounds).

### Minimum Reach Requirements with *Un-Locked Reels*

The pilot must be able to actuate the primary flight controls simultaneously (stick, pedals, brakes, throttles) through the full range of motion while seated in a position to manipulate every cockpit switch, lever, circuit breaker, or handle and be in a position to see to land.

### Minimum Requirements with *Locked Inertial Reels*

- The pilot must be able to actuate the primary flight controls simultaneously (stick, pedals, brakes, throttles) through the full range of motion while seated in a position to see to land.
- The pilot must be able to pull both ejection handles. (Flight Manual Ejection Sequence)
- The pilot must be able to reach the Canopy Jettison. (Flight Manual Ditching Procedure)
- The pilot must be able to unlock the inertial reel/shoulder harness.

## B-1 Body Size/Reach Requirements

### Measurement Assumptions

Body measurements are to be taken with full combat, adverse weather gear as well as in chemical warfare ensemble.

### Vision Requirement

Pilots must be able to sit at the design eye point while at the same time being able to manipulate the flight controls (stick, pedals, brakes, throttles) through the full range of motion.

### Body Clearances/Size Requirements

- The pilot's helmet should not hit the canopy during tactical maneuvers; there should be no interference with head movements.
- The pilot's shins should not come in contact with the main instrument panel.
- The pilot should have full stick clearance with thighs so that the full range of stick motion is available.
- The pilot should not come into contact with any aircraft structure on ejection or be restricted by an aircraft structure upon ground egress.
- The pilot's weight must meet ejection seat envelope requirements (ACES II naked body weight envelope is 140 to 211 pounds).

### Minimum Reach Requirements with *Un-Locked Reels*

The pilot must be able to actuate the primary flight controls simultaneously (stick, pedals, brakes, throttles) through the full range of motion while seated in a position to manipulate every cockpit switch, lever, circuit breaker, or handle on their side of the cockpit as well as both pilots need to be able to reach the switches on the overhead panels, center instrument panel, and center console and be in a position to see to land.

### Minimum Requirements with *Locked Inertial Reels*

- The pilot must be able to actuate the primary flight controls simultaneously (stick, pedals, brakes, throttles) through the full range of motion while seated in a position to see to land.
- The pilot must be able to actuate the ejection handles and hatch Jettison required during ejection sequence (Flight Manual Ejection Sequence).
- The pilot must be able to unlock the inertial reel/shoulder harness.
- The co-pilot must be able to actuate the Landing Gear Handle. (Flight Manual Gear-up Landing Go Around procedure).

## B-2 Body Size/Reach Requirements

### Measurement Assumptions

Body measurements are to be taken with full combat, adverse weather gear.

### Vision Requirement

Pilots must be able to sit at the design eye point while at the same time being able to manipulate the flight controls (stick, pedals, brakes, throttles) through the full range of motion.

### Body Clearances/Size Requirements

- The pilot's helmet should not hit the overhead structure. There should be no interference with head movements.
- The pilot's shins should not come in contact with the forward instrument panels.
- The pilot should have full stick clearance with thighs so that the full range of stick motion is available.
- The pilot should not come into contact with any aircraft structure on ejection or be restricted by an aircraft structure upon ground egress.
- The pilot's weight must meet ejection seat envelope requirements (ACES II naked body weight envelope is 140 to 211 pounds).

### Minimum Reach Requirements with *Un-Locked Reels*

The pilot must be able to actuate the primary flight controls simultaneously (stick, pedals, brakes, throttles) through the full range of motion while seated in a position to actuate every cockpit switch, lever, button, or handle on their side of the cockpit as well as reach the switches on the center instrument and overhead panels and center console and be in a position to see to land.

### Minimum Requirements with *Locked Inertial Reels*

- The pilot must be able to actuate the primary flight controls simultaneously (stick, pedals, brakes, throttles) through the full range of motion while seated in a position to see to land.
- The pilot must be able to actuate the ejection handles.
- The pilot must be able to unlock the inertial reel/shoulder harness.

## B-52 Body Size/Reach Requirements

### Measurement Assumptions

Body measurements are to be taken with full combat, adverse weather gear as well as in chemical warfare ensemble.

### Vision Requirement

Pilots must be able to sit at the design eye point while at the same time being able to manipulate the flight controls (yoke, pedals, brakes, throttles) through the full range of motion.

### Body Clearances/Size Requirements

- The pilot's helmet should not hit the overhead hatch during tactical maneuvers; there should be no interference with head movements.
- The pilot's shins should not come in contact with the forward instrument panel.
- The pilot should have full yoke clearance with thighs so that the full range of yoke motion is available.
- The pilot should not come into contact with any aircraft structure on ejection or be restricted by an aircraft structure upon ground egress.

### Minimum Reach Requirements with *Un-Locked Reels*

Pilots must be able to reach switches, levers, circuit breakers, and handles on their side of the cockpit. Both pilots must be able to reach the landing gear handle and fire shutoff switches. Additionally, the copilot must be able to reach the electrical control panel with both hands simultaneously.

### Minimum Requirements with *Locked Inertial Reels*

- The pilot must be able to actuate the primary flight controls simultaneously (yoke, pedals, brakes, throttles) through the full range of motion while seated in a position to see to land.
- The pilot must be able to actuate the ejection arming levers. (Flight Manual Ejection Sequence)
- The pilot must be able to unlock the inertial reel/shoulder harness.

C-130 Operational Requirements

Vision Requirements

Pilots must be able to see the aim point at the end of the runway during a no flap landing. For HUD equipped aircraft, the pilots must see all primary flight information/symbology.

*While in that seat position, both left and right seat pilots must accomplish the following:*

Minimum Reach Requirements with *UN-Locked Reels*

Pilot and Co-pilot Requirements:

- Both the left seat and right seat pilots must be able to move the Throttles for all engines throughout their complete range.
- Both the left and right seat pilots must be able to move the Yoke left and right to the stops.
- Both the left and right seat pilots must be able to move the Yoke forward and aft to the stops.
- Both the left and right seat pilots must be able to move the Yoke aft left and right to the stops.
- Both the left and right seat pilots must be able to actuate their Inertial Reel locks.
- Both the left and right seat pilots must be able to actuate the Flap Lever.
- Both the left and right seat pilots must be able to actuate all Fire T-Handles.
- Both the left and right seat pilots must be able to actuate the condition levers for Air Start and Feathers operations.
- Both the left and right seat pilots must be able to reach their Oxygen Masks.

Pilot Specific Requirements:

- The pilot must be able to perform a dual reach; they must be able to actuate the Nose Wheel Steering and Throttles.
- The pilot must be able to actuate all of the Engine Starter switches.
- The Pilot must be able to actuate the Repeater Flight Command Indicator panel on the glareshield.
- The Pilot must be able to actuate the manual emergency depressurization handle.

Co-Pilot Specific Requirements:

- The Co-pilot must be able to actuate the Prop Control switches.
- The Co-pilot must be able to actuate the Brake Select Switch as well as all engine hydraulic pump switches.
- The Co-pilot must be able to perform a dual reach for airdrop; they must actuate the Jump Light switch as well as the Air Drop System (ADS) chute release switch or Flap Handles simultaneously.
- The Co-pilot must be able to actuate reach the Landing Gear Handle.
- The Co-pilot must be able to actuate the wing flap control circuit breaker.

- The Co-pilot must be able to actuate the landing gear control circuit breaker.

Minimum Requirements with *Locked Inertial Reels*

Pilot and Co-Pilot Requirements:
- The left and right seat pilots must be able to move the Yoke left and right to the stops.
- The left and right seat pilots must be able to move the Yoke forward and aft to the stops.
- The left and right seat pilots must be able to move the Yoke aft left and right to the stops.
- The left and right seat pilots must be able to actuate their Inertial Reel locks.

Pilot Specific Requirements:
- The pilot must be able to move the Throttles for all engines throughout their complete range.

Co-Pilot Specific Requirements:
- The Co-Pilot must be able to actuate the Landing Gear Handle.

Rudder Requirements:
- The Pilot and Co-pilot must be able to achieve full rudder deflection.
- The pilot(s) must be able to achieve full rudder deflection while simultaneously achieving maximum application of both brakes.

C-141 Operational Requirements

Vision Requirements

Pilots must be able to see the aim point at the end of the runway during a no flap landing.

*While in that seat position, both left and right seat pilots must accomplish the following:*

Minimum Requirements with *Un-Locked Reels*

Pilot and Co-pilot Requirements:

- Both the left seat and right seat pilots must be able to move the Throttles for all engines throughout their complete range.
- Both the left and right seat pilots must be able to move the Yoke left and right to the stops.
- Both the left and right seat pilots must be able to move the Yoke forward and aft to the stops.
- Both the left and right seat pilots must be able to move the Yoke aft left and right to the stops actuate
- Both the left and right seat pilots must be able to actuate their Inertial Reel Locks.
- Both the left and right seat pilots must be able to actuate all Fire T-Handles (1-4).

Pilot Specific Requirements:

- The Right seat pilot must be able to actuate the Engines Starts (1-4).
- The Right seat pilot must be able to actuate the Ignition Switch.
- The Pilot must be able to reach Oxygen Masks.

Co-Pilot Specific Requirements:

- The Co-pilot must be able to actuate the Flap Handle.

Minimum Requirements with *Locked Inertial Reels*

Pilot and Co-Pilot Requirements:

- Both the left seat and right seat pilots must be able to move the Throttles for all engines throughout their complete range.
- The left and right seat pilots must be able to move the Yoke left and right to stops.
- The left and right seat pilots must be able to move the Yoke forward and aft to stops.
- The left and right seat pilots must be able to move the Yoke full aft left and right to stops.
- The left and right seat pilots must be able to actuate their Inertial Reel Locks.

Pilot Specific Requirements:

- The Pilot must actuate all Fire T-handles.

Co-Pilot Specific Requirements:

- The Co-Pilot must be able to actuate the Landing Gear Handle.

Rudder Requirements:

- The pilot(s) must be able to achieve full Rudder deflection
- The pilot(s) must be able to achieve full Rudder deflection while simultaneously achieving maximum application of both brakes.

C-17 Operational Requirements

Vision Requirement

Pilots must be able to sit high enough to see all HUD symbology

*While in that seat position, both left and right seat pilots must accomplish the following:*

Minimum Reach Requirements with *Un-Locked Reels*

Pilot and Co-pilot Requirements:

- Both the left seat and right seat pilots must be able to move the Throttles for all engines throughout their complete range.
- Both the left and right seat pilots must be able to move the Stick full left and right to the stops.
- Both the left and right seat pilots must be able to move the Stick full forward and aft to the stops.
- Both the left and right seat pilots must be able to move the Stick full aft left and right to the stops.
- Both the left and right seat pilots must be able to actuate their inertial reel locks.
- Both the left and right seat pilots must be able to actuate the Flap Handle.
- Both the left and right seat pilots must be able to actuate all Fire T-Handles.
- Both the left and right seat pilots must be able to actuate the Engine Starters Switches(1-4).
- Both the left and right seat pilots must be able to reach their Oxygen Masks.
- Both the left and right seat pilots must be able to actuate the Pilot Interphones.
- Both the left and right seat pilots must be able to fully open the universal aerial refueling receptacle slipway installation (UARRSI) handle.
- Both the left and right seat pilots must be able to actuate UARRSI L Master and Override Remote Control Circuit Breaker on the overhead circuit breaker panel.
- Both the left and right seat pilots must be able to actuate the MFC, MCK, and MCD.
- Both the left and right seat pilots must be able to actuate the Nose Wheel Steering.
- Both the left and right seat pilots must be able to actuate all the system switches on the overhead panel.

Co-Pilot Specific Requirements:

- The Co-Pilot must be able to actuate the Landing Gear Handle.

Minimum Requirements with *Locked Inertial Reels*

Pilot and Co-Pilot Requirements:

- Both the left seat and right seat pilots must be able to move the Throttles for all engines throughout their complete range.
- The left and right seat pilots must be able to move the Stick forward left and right to stops.

- The left and right seat pilots must be able to move the Stick full aft left and right to stops.
- The left and right seat pilots must be able to move the Stick full forward and full aft.
- The left and right seat pilots must be able to actuate their inertial reel locks.
- The left and right seat pilots must be able to actuate all Fire T-Handles.

Co-Pilot Specific Requirements:

- The Co-Pilot must be able to actuate the landing gear handle.

Rudder Requirements:

- Both the Left and Right seat pilots must able to achieve full rudder deflection.
- The pilot(s) must be able to achieve full rudder deflection while simultaneously achieving maximum application of both brakes.

## C-21 Operational Requirements

Vision Requirements

To land the aircraft safely the pilot must be able to see enough over the glareshield to see cues for the landing aim point.

*While in that seat position, both left and right seat pilots must accomplish the following:*

Minimum Requirements with *Un-Locked Reels*

Pilot and Co-pilot Requirements:

- Both the left seat and right seat pilots must be able to move the Throttles for all engines throughout their complete range.
- Both the left and right seat pilots must be able to move the Yoke left and right to the stops.
- Both the left and right seat pilots must be able to move the Yoke forward and aft to the stops
- Both the left and right seat pilots must be able to move the Yoke forward left and right to the stops.
- Both the left and right seat pilots must be able to move the Yoke aft left and right to the stops.
- Both the left and right seat pilots must be able to actuate the Landing Gear Handle.
- Both the left and right seat pilots must be able to actuate all the Fire Handles.

Pilot Specific Requirements:

- The Pilot must be able to reach the strap for the EEBD.

Co-Pilot Specific Requirements:

- The Co-pilot must be able to actuate the Emergency Gear Extension Handle.

Minimum Requirements with *Locked Inertial Reels*

Pilot and Co-Pilot Requirements:

- Both the left seat and right seat pilots must be able to move the Throttles for all engines throughout their complete range.
- The left and right seat pilots must be able to move the Yoke left and right to stops.
- The left and right seat pilots must be able to move the Yoke forward and aft to stops.
- The left and right seat pilots must be able to actuate all Fire T-Handles.

Co-Pilot Specific Requirements:

- The Co-Pilot must be able to actuate the Landing gear handle.

<u>Rudder Requirements:</u>

- The pilots must be able to achieve full rudder deflection.
- The pilot(s) must be able to achieve full rudder deflection while simultaneously achieving maximum application of both brakes.

C-5 Operational Requirements

Vision Requirements

The pilot must be able to see the aim point at the end of the runway during a no flap landing.

*While in that seat position, both left and right seat pilots must accomplish the following:*

Minimum Requirements with *Un-Locked Reels*

Pilot and Co-pilot Requirements:

- Both the left seat and right seat pilots must be able to move the Throttles for all engines throughout their complete range.
- Both the left and right seat pilots must be able to move the Yoke left and right to the stops.
- Both the left and right seat pilots must be able to move the Yoke forward and aft to the stop
- Both the left and right seat pilots must be able to actuate their Inertial Reel locks.
- Both the left and right seat pilots must be able to actuate the Flap Handle.
- Both the left and right seat pilots must be able to actuate all Fire T-Handles.
- Both the left and right seat pilots must be able to actuate the landing lights.

Pilot Specific Requirements:

- The pilot must be able to actuate the Tiller.
- The pilot must be able to reach perform a dual reach, they must be able to actuate the Nose Wheel Steering and the Caster Switch simultaneously.

Co-Pilot Specific Requirements:

- The Co-pilot must be able to actuate the Landing Gear Handle.
- The Co-pilot must be able to actuate all Hydraulic Power Switches.
- The Co-Pilot must be able to actuate the Rudder Limiter Switch on the Overhead Panel.

Minimum Requirements with *Locked Inertial Reels*

Pilot and Co-Pilot Requirements:

- Both the left seat and right seat pilots must be able to move the Throttles for all engines throughout their complete range.
- The left and right seat pilots must be able to move the Yoke left and right to stops.
- The left and right seat pilots must be able to move the Yoke forward and aft to stops.
- The left and right seat pilots must be able to actuate their Inertial Reel locks.

Co-Pilot Specific Requirements:

- The Co-Pilot must be able to actuate the Landing Gear Handle.

Rudder Requirements:

- The pilots must be able to achieve full rudder deflection.
- The pilots must be able to achieve full rudder deflection while simultaneously achieving maximum application of both brakes.

## F-117A Body Size/Reach Requirements

Measurement Assumptions

Body measurements are to be taken with full combat, adverse weather gear as well as in chemical warfare ensemble. G-Suit should be inflated.

Vision Requirement

Pilots must be able to sit at the design eye point while at the same time being able to manipulate the flight controls (stick, pedals, brakes, throttles) through the full range of motion.

Body Clearances/Size Requirements:

- The pilot's helmet should not hit the canopy during tactical maneuvers; there should be no interference with head movements.
- The pilot's shins should not come in contact with the main instrument panel.
- The pilot should have full stick clearance with thighs so that the full range of stick motion is available with G-Suit inflated.
- The pilot should not come into contact with any aircraft structure on ejection or be restricted by an aircraft structure upon ground egress.
- The pilot's weight must meet ejection seat envelope requirements (ACES II naked body weight envelope is 140 to 211 pounds).

Minimum Reach Requirements with *Un-Locked Reels*

The pilot must be able to actuate the primary flight controls simultaneously (stick, pedals, brakes, throttles) through the full range of motion while seated in a position to manipulate every cockpit switch, lever, circuit breaker, or handle and be in a position to see to land.

Minimum Requirements with *Locked Inertial Reels*

- The pilot must be able to actuate the primary flight controls simultaneously (stick, pedals, brakes, throttles) through the full range of motion while seated in a position to see to land.
- The pilot must be able to actuate the ejection handles, alternate canopy/seat T-handles, and canopy latch handle and switch during ejection sequence. (Flight Manual Ejection Sequence)
- The pilot must be able to unlock the inertial reel/shoulder harness.
- The pilot must be able to actuate the Drag Chute during approach-end arrestment. (Flight Approach-End Arrestment procedure)
- The pilot must be able to actuate the INERT switch during landing gear system emergencies. (Flight Manual Landing Gear System Emergencies procedure)

F-15 Body Size/Reach Requirements

Measurement Assumptions

Body measurements are to be taken with full combat, adverse weather gear as well as in chemical warfare ensemble. G-Suit should be inflated.

Vision Requirement

Pilots must be able to sit at the design eye point while at the same time being able to manipulate the flight controls (stick, pedals, brakes, throttles) through the full range of motion.

Body Clearances/Size Requirements

- The pilot's helmet should not hit the canopy during tactical maneuvers; there should be no interference with head movements.
- The pilot's shins should not come in contact with the main instrument panel.
- The pilot should have full stick clearance with thighs so that the full range of stick motion is available with G-Suit inflated.
- The pilot should not come into contact with any aircraft structure on ejection or be restricted by an aircraft structure upon ground egress.
- The pilot's weight must meet ejection seat envelope requirements (ACES II naked body weight envelope is 140 to 211 pounds).

Minimum Reach Requirements with *Un-Locked Reels*

The pilot must be able to actuate the primary flight controls simultaneously (stick, pedals, brakes, throttle(s)) through the full range of motion while seated in a position to manipulate every cockpit switch, lever, circuit breaker, or handle and be in a position to see to land.

Minimum Requirements with *Locked Inertial Reels*

- The pilot must be able to actuate the primary flight controls simultaneously (stick, pedals, brakes, throttles) through the full range of motion while seated in a position to see to land.
- The pilot must be able to reach the ejection handles. (Flight Manual Ejection Sequence)
- The pilot must be able to actuate the Canopy Jettison. (Flight Manual Canopy Jettison Procedure)
- The pilot must be able to reach the Emergency Brake/Steering Handle. (Flight Manual APPROACH END CABLE ENGAGEMENT)

F-16 Body Size/Reach Requirements

Measurement Assumptions

Body measurements are to be taken with full combat, adverse weather gear as well as in chemical warfare ensemble. G-Suit should be inflated.

Vision Requirement

Pilots must be able to sit at the design eye point while at the same time being able to manipulate the flight controls (stick, pedals, brakes, throttle) through the full range of motion.

Body Clearances/Size Requirements

- The pilot's helmet should not hit the canopy during tactical maneuvers; there should be no interference with head movements. There should be 2.25 inches of clearance between the pilot's helmet and the canopy due to Canopy deflection during a bird strike.
- The pilot's shins should not come in contact with the main instrument panel.
- The pilot should have full stick clearance between thigh and side stick so that the full range of stick motion is available with G-Suit inflated.
- The pilot should not come into contact with any aircraft structure on ejection or be restricted by an aircraft structure upon ground egress.
- The pilot's weight must meet ejection seat envelope requirements (ACES II naked body weight envelope is 140 to 211 pounds).

Minimum Reach Requirements with *Un-Locked Reels*

The pilot must be able to actuate the primary flight controls simultaneously (stick, pedals, brakes, throttle) through the full range of motion while seated in a position to manipulate every cockpit switch, lever, circuit breaker, or handle and be in a position to see to land.

Minimum Requirements with *Locked Inertial Reels*

- The pilot must be able to actuate the primary flight controls simultaneously (stick, pedals, brakes, throttle) through the full range of motion while seated in a position to see to land.
- The pilot must be able to actuate the ejection handle with G-Suit inflated. (Flight Manual Ejection Sequence)
- The pilot must be able to actuate the Canopy handle, MANUAL CANOPY CONTROL handcrank and Canopy Jettison handle. (Flight Manual Failure of canopy to separate during ejection).
- The pilot must be able to unlock the inertial reel/shoulder harness.

H-1 Operational Requirements

Vision Requirement

Pilots must see at least –5 degrees over the glareshield for seeing/clearing forward of the aircraft during level flight.

From that seat position Pilots must accomplish the following:

Minimum Reach Requirements with *Un-Locked Reels*

<u>Pilot and Co-pilot Requirements:</u>

- Both the left seat and right seat pilots must be able to move the throttle throughout it's entire range.
- Both the left and right seat pilots must be able to move the Cyclic full forward and aft to the stops.
- Both the left and right seat pilots must be able to move the Cyclic full aft/left and full aft/right to the stops.
- Both the left and right seat pilots must be able to move the Collective the full range.
- Both the left and right seat pilots must be able to actuate all the Fire T-Handles.
- Both the left and right seat pilots must be able to actuate reach the Radio controls.

Minimum Requirements with *Locked Inertial Reels*

<u>Pilot and Co-Pilot Requirements:</u>

- Both the left and right seat pilots must be able to move the throttle throughout it's entire range.
- Both the left and right seat pilots must be able to move the Cyclic forward and aft to stops.
- Both the left and right seat pilots must be able to move the Cyclic full aft/left and full aft/right to stops.
- Both the left and right seat pilots must be able to move the Collective to the stops

<u>Rotor Pedal Requirements:</u>

- The pilot(s) must able to achieve full rotor pedal deflection.

## H-53J Operational Requirements

### Vision Requirement

Pilots must be able to see the extended refueling probe from the left seat. Pilots cannot stretch to see this point. Stretching should be used as a reserve safety margin.

From that position pilots must be able to accomplish the following:

### Minimum Reach Requirements with *Un-Locked Reels*

<u>Pilot and Co-pilot Requirements:</u>

- Both the left seat and right seat pilots must be able to move the Throttle throughout it's entire range.
- Both the left and right seat pilots must be able to move the Cyclic full forward and aft to the stops.
- Both the left and right seat pilots must be able to move the Cyclic full aft/left and full aft/right to the stops.
- Both the left and right seat pilots must be able to move the Cyclic full forward/left and full forward/right to the stops
- Both the left and right seat pilots must be able to move the Collective the full range.
- Both the left and right seat pilots must be able to actuate all the Fire T-Handles.
- Both the left and right seat pilots must be able to reach the Landing Gear (panel).
- Both the left and right seat pilots must be able to actuate the Intercom Selector.
- Both the left and right seat pilots must be able to actuate the Radar Altimeter.
- Both the left and right seat pilots must be able to actuate the Jettison off Fuel Tanks.

<u>Co-Pilot Specific Requirements:</u>

- The Co-Pilot must be able to actuate the Radios

### Minimum Requirements with *Locked Inertial Reels*

Both the left and right seat pilots are required to fly with their reels locked in some tactical missions.

<u>Pilot and Co-Pilot Requirements:</u>

- Both the left and right seat pilots must be able to move the Throttle throughout it's full range
- Both the left and right seat pilots must be able to move the Cyclic forward and aft to stops.
- Both the left and right seat pilots must be able to move the Cyclic full aft/left and full aft/right to stops.
- Both the left and right seat pilots must be able to move the Collective to the stops

<u>Rotor Pedal Requirements:</u>

- The pilot(s) must able to achieve full rotor pedal deflection.

## HH-60G Body Size/Reach Requirements

Measurement Assumptions:

Body measurements are to be taken with full combat, adverse weather gear as well as in chemical warfare ensemble.

Vision Requirement:

Pilots must be able to sit at the design eye point while at the same time being able to manipulate the flight controls simultaneously (cyclic, collective, tail rotor pedals, and brakes) through the full range of motion.

Body Clearances/Size Requirements

- The pilot's helmet should not hit the greenhouse or overhead console during tactical maneuvers; there should be no interference with head movements.
- The pilot's shins should not come in contact with the main instrument panel.
- The pilot should have full cyclic clearance with thighs so that the full range of cyclic motion is available.
- The pilot should not come into contact with any airframe structure or be restricted by an aircraft structure upon ground egress.

Minimum Reach Requirements with *Un-Locked Reels*:

Both pilots must be able to actuate the primary flight controls simultaneously (cyclic, collective, tail rotor pedals, and brakes) through the full range of motion while seated in a position to manipulate every cockpit switch, lever, circuit breaker, or handle on their side of the cockpit as well as both pilots must be able to reach all switches on the overhead, lower, and aft consoles and be in a position to see to land.

The Copilot must be able to simultaneously place either throttle in ECU Lock-out and hold it there with one hand while at the same time holding the Fuel Pump switch in Fuel Prime with the other hand. *(Flight Manual Engine Priming Procedure)*

Minimum Requirements with *Locked Inertial Reels*:

- Both pilots must be able to actuate the primary flight controls simultaneously (cyclic, collective, tail rotor pedals, and brakes) through the full range of motion while seated in a position to see to land.

- Both pilots must be able to unlock their inertial reel/shoulder harness.
- Both pilots must be able to reach to pull both throttles to OFF *(Flight Manual Planned Ditching Procedure).*

KC-10 Operational Requirements

Vision Requirements

- To land the aircraft safely the pilot must be able to see enough over the glareshield to see cues for the landing aim point.

*While in that seat position, both left and right seat pilots must accomplish the following:*

Minimum Requirements *with Un-Locked Reels*:

Pilot and Co-pilot Requirements:

- Both the left seat and right seat pilots must be able to move the Throttles for all engines throughout their complete range.
- Both the left and right seat pilots must be able to move the Yoke left and right to the stops.
- Both the left and right seat pilots must be able to move the Yoke forward and aft to the stops.
- Both the left and right seat pilots must be able to actuate the Landing Gear handle.
- Both the left and right seat pilots must be able to actuate the Flap Handle.
- Both the left and right seat pilots must be able to actuate all Fire T-Handles.
- Both the left and right seat pilots must be able to actuate the Radar switch.
- Both the left and right seat pilots must be able to actuate the HF Radio switch.

Co-Pilot Specific Requirements:

- The Co-pilot must be able to actuate the Spoiler Handle.
- The Co-Pilot must be able to actuate both Flight Director Switches.
- The Co-Pilot must be able to actuate the Standby Altimeter.

Minimum Requirements with *Locked Inertial Reels*:

Pilot and Co-Pilot Requirements:

- Both the left seat and right seat pilots must be able to move the Throttles for all engines throughout their complete range.
- The left and right seat pilots must be able to move the Yoke left and right to stops.
- The left and right seat pilots must be able to move the Yoke forward and aft to stops.
- The left and right seat pilots must be able to actuate all the Fire T-Handles.

Co-Pilot Specific Requirements:

- The Co-Pilot must be able to actuate the Landing Gear Handle.
- The Co-Pilot must be able to actuate the Emergency Power switch.

Rudder Requirements:

- The pilots must be able to achieve full rudder deflection.
- The pilots must be able to achieve full rudder deflection while simultaneously achieving maximum application of both brakes.

## KC-135 Operational Requirements

Vision Requirements

The pilot must be able to see the aim point at the end of the runway in a no-flap landing.

*While in that seat position, both left and right seat pilots must accomplish the following:*

Minimum Requirements with *Un-Locked Reels*

Pilot and Co-pilot Requirements:

- Both the left seat and right seat pilots must be able to move the Throttles for all engines throughout their complete range.
- Both the left and right seat pilots must be able to move the Yoke left and right to the stops.
- Both the left and right seat pilots must be able to move the Yoke full aft left and right to stops.
- Both the left and right seat pilots must be able to move the Yoke forward and aft to stops.
- Both the left and right seat pilots must be able to actuate the Flap Handle.
- Both the left and right seat pilots must be able to actuate all Fire T-Handles.
- Both the left and right seat pilots must be able to actuate the Trim Cut off Switch.
- Both the left and right seat pilots must be able to actuate the Landing Gear Handle.
- Both the left and right seat pilots must be able to actuate the Rudder Power Switch.
- Both the left and right seat pilots must be able to actuate their Inertial Reel Locks.

Pilot Specific Requirements:

- The pilot must be able to actuate the Battery On/Off Switch.
- The pilot must be able to reach perform a dual reach, they must be able to actuate the Nose Wheel Steering and the Throttles simultaneously.

Minimum Requirements with *Locked Inertial Reels*:

Pilot and Co-Pilot Requirements:

- Both the left seat and right seat pilots must be able to move the Throttles for all engines throughout their complete range.
- Both the left and right seat pilots must be able to move the Yoke left and right to stops.
- Both the left and right seat pilots must be able to move the Yoke forward and aft to stops.
- Both the left and right seat pilots must be able to move the Yoke full aft left and right.
- Both the left and right seat pilots must be able to r actuate their inertial reel locks.
- Both the left and right seat pilots must be able to actuate all Fire T-Handles.

Co-Pilot Specific Requirements:

- The Co-Pilot must be able to actuate the Landing gear handle.

Rudder Requirements:

- The pilot(s) must be able to achieve full rudder deflection.
- The pilot(s) must be able to achieve full rudder deflection while simultaneously achieving maximum application of both brakes.

## T-1 Cockpit Accommodation Operational Requirements

### Vision Requirements

Pilots must be able to see the runway during both normal and heavyweight no-flap approaches without stretching or tilting their heads up and back to see over the nose. This equates to a minimum Over-the-Nose Vision angle of -10 degrees in a no flap landing.

### Body Clearances Requirements

- The pilot's shins should not have contact with the main instrument panel.
- The pilot must be able to move yoke to all positions: full forward and full aft, roll left and right to the stops. (The pilot can move his or her legs to achieve yoke movement.)
- The pilot must be able to achieve full rotational yoke motion while moving the yoke from a neutral to a full aft position. In addition, these conditions must be achievable while obtaining full rudder deflection in either direction. The aforesaid condition must be met without unlatching the pilot's harness. (These conditions are required during landings in severe crosswinds. Subjects encountered a few incidences of pulling the yoke full aft and then rolling the yoke. It contacted the harness buckle and released the harness.)

### Reach to Controls with Locked Reels Requirements

- The pilot must reach the Emergency Brake Handle. (Comments from interviews: This is an emergency requirement for landing without normal brakes.)
- The pilot must be able to get full range of Throttles, to retard them from full forward. (Comments from interviews: Used for any emergency involving engine trouble.)
- The pilot must reach the Landing Gear Lever. (Comments from interviews: Pilots must be able to reach this while sustaining 1-2 g's.)
- The pilot must be able to move the yoke to all positions: full forward and full aft, roll left and right to the stops.
- The pilot must be able to reach the Inertial Lock release.

### Rudder Requirements

The pilot must be able to reach Full Rudder with Toe Brakes (Comments from interviews: Necessary for single engine emergencies, crosswind landings, and for a blown tire.)

## T-37 Cockpit Accommodation Operational Requirements

### Vision Requirements

Pilots must be able to see the runway during both normal and heavyweight no-flap approaches without stretching or tilting their heads up and back to see over the nose. This equates to a minimum Over-the-Nose Vision angle of -8.5 degrees relative to the aircraft waterline.

### Body Clearances Requirements

- Pilots must not have a Buttock-Knee length greater than 27.3 inches (this includes a one inch safety margin). This is the maximum Buttock-Knee for canopy-bow leg clearance while ejecting from the T-37.
- The pilot's shins should not come in contact with the main instrument panel. The 27.3" limit covers this.

### Reach to Controls with Locked Reels Requirements

- The pilot must reach the ejection handles.
- The pilot must be able to achieve full forward stick with neutral ailerons and full aft stick with full aileron deflection. In addition, these conditions must be achievable while obtaining full rudder deflection in either direction. (Pilot comments: These requirements are driven by spin entry requirements, crosswind landing requirements and spin prevention and recovery requirements).
- The pilot must be able to reach the full range of motion on the throttles with the reels locked. (Pilot comments: Must have full range of motion for throttles for spin recovery.)
- The pilot must be able to reach the Flaps with the reels locked.
- The pilot must be able to reach the inertial reel lock.

### Rudder Requirements

The pilot must be able to achieve full rudder deflection while applying full braking to both rudder pedals. (Pilot comments: Rudders are needed for spin recovery, crosswind landing, and brake failure. This requirement is driven by the demands made on the pilots by a failed tire during takeoff or landing.)

## T-38 Operational Requirements

### Vision Requirement

Pilots must be able to sit at the T-38 design eye point. This is needed to be able to see the aim point on the runway during a no-flap landing, Wingman in a formation re-join, and the HUD symbology in the T-38C.

### Body Clearances Requirements

- The Pilot's helmet should not hit the canopy. There should be no contact during maneuvers and there should be no interference with head movements.
- The pilot's shins should not come in contact with the main instrument panel.
- The pilot should have full stick clearance with thighs so that the full range of stick motion is available.
- The pilot should not come into contact with any aircraft structure on ejection.

### Minimum Reach Requirements with *Un-Locked Reels*

- The pilot must be able to reach all the controls including all of the Circuit Breakers.

### Minimum Requirements with *Locked Inertial Reels*

- The pilot must be able to move the Throttle through its full range.
- The pilot must be able to engage the Speed Brake
- The pilot must be able to actuate the Inertial Reel lock.
- The pilot must be able to actuate the Ejection Handles.

### Rudder Requirements:

- The pilot must able to achieve full rudder deflection.
- The pilot must able to achieve full rudder deflection with toe brakes

## APPENDIX D: STAFF SUMMARY SHEETS ON ANTHROPOMETRIC OPERATIONAL REQUIREMENTS

AETC Staff Summary Sheet for T-1, T-37, T-6

**Staff Summary Sheet** 2283

| | To | Action | Signature (Surname), Grade, Date | | To | Action | Signature (Surname), Grade, Date |
|---|---|---|---|---|---|---|---|
| 1 | 99FTS/DO | Coord | Kotowski, LtCol 6 Oct | 12 | 19 AF/DO | Coord | Rogers, Col 7 Dec |
| 2 | 559 FTS/DO | Coord | Craft, LtCol 3 Oct | 13 | HQ AETC/XP | Coord | Winterberger, BG 23 Oct |
| 3 | 557 FTS/DO | Coord | Kimsey, LtCol 7 Oct | 14 | 12 FTW/CC | Coord | Stevenson, BG 2 Dec |
| 4 | HQ AETC/DOFI | Coord | Johnson, LtCol 28 Sep | 15 | HQ AETC/SG | Coord | Morgan, Col 1 Nov |
| 5 | HQ AETC/SGPA | Coord | Van Syoc, Col 28 Sep | 16 | 19 AF/CC | Coord | See memo Polk, MG 13 Dec |
| 6 | 99 FTS/CC | Coord | Waters, LtCol 6 Oct | 17 | HQ AETC/DO | Coord | Welser MG 23 Dec |
| 7 | 559 FTS/CC | Coord | Britton, LtCol 4 Oct | 18 | HQ AETC/CCX | Coord | LtCol 29 Dec |
| 8 | 557 FTS/CC | Coord | Poronsky, LtCol 7 Oct | 19 | HQ AETC/DS | Coord | LV |
| 9 | HQ AETC/DOF | Coord | Gilbert, Col 29 Sep | 20 | AETC/CV | Appr | Gen 12/30/99 |
| 10 | HQ AETC/SGP | Coord | Rake, Col 29 Sep | 21 | | | |
| 11 | 12 FTW/OG | Coord | Hoog, Col 27 Oct | 22 | | | |

| Grade and Surname of Action Officer | Symbol | Phone | Suspense Date |
|---|---|---|---|
| Davis, LaDonna J. Capt | AETC SAS/TE | DSN 487-5517 | |

| Subject | SSS Date |
|---|---|
| AETC Training Aircraft Cockpit Accommodation Series (CAS) Operational Requirements | 20 Oct 99 |

AETC Staff Summary Sheet for T-38

**STAFF SUMMARY SHEET** 2482

| | TO | ACTION | SIGNATURE (Surname), GRADE AND DATE | | TO | ACTION | SIGNATURE (Surname), GRADE AND DATE |
|---|---|---|---|---|---|---|---|
| 1 | AETC/ CC | Approv | 3 Dec | 6 | | | |
| 2 | AETC/ CV | Coord | LG 13 | 7 | | | |
| 3 | AETC/ DS | Coord | Col (21) | 8 | | | |
| 4 | | | | 9 | | | |
| 5 | | | | 10 | | | |

| SURNAME OF ACTION OFFICER AND GRADE | SYMBOL | PHONE | TYPIST'S INITIALS | SUSPENSE DATE |
|---|---|---|---|---|
| Lt Col Hennager | XPRF | 74073 | lcm | |

| SUBJECT | DATE |
|---|---|
| T-38 Anthropometric Requirements | 17 OCT 1997 |

AMC Staff Summary Sheet for C-130, C-5, C-17, KC-10, KC-135, C-141, C-21

**STAFF SUMMARY SHEET**

| | TO | ACTION | SIGNATURE (Surname) GRADE & DATE | | TO | ACTION | SIGNATURE (Surname) GRADE & DATE |
|---|---|---|---|---|---|---|---|
| 1 | SG | Coord | Love, Col 5 Jul 00 | 6 | | | |
| 2 | SE | Coord | Ziegler, Col 5 Jul 00 | 7 | | | |
| 3 | XP | Coord | Lichte, Maj Gen 17 Jul 00 | 8 | | | |
| 4 | CV | Coord | [illegible] | 9 | | | |
| 5 | CC | Approve | [illegible] | 10 | | | |

| SURNAME AND GRADE OF ACTION OFFICER | OFFICE SYMBOL | PHONE | TYPIST'S INITIALS | SUSPENSE DATE |
|---|---|---|---|---|
| MSgt Elson | DOTK | 256-5052 | DEE | |

| SUBJECT | DATE |
|---|---|
| Aircraft Cockpit Series (CAS) Study Support Request (CMD-001734) | 19 JUL 2000 |

AFSOC Staff Summary Sheet for H-53, H-1

**STAFF SUMMARY SHEET**

| | TO | ACTION | SIGNATURE (Surname), GRADE AND DATE | | TO | ACTION | SIGNATURE (Surname), GRADE AND DATE |
|---|---|---|---|---|---|---|---|
| 1 | XP | Coord | [illegible] | 6 | XP | Sign | [illegible] |
| 2 | SE | Coord | COMMENTS [illegible] Col, 18 MAY 00 | 7 | | | |
| 3 | SG | Coord | [illegible] Col 24 May 00 | 8 | | | |
| 4 | DS | Coord | Spencer, Col 2 Jun | 9 | | | |
| 5 | CV | Appr | [illegible] Johnson B/G 5 Jun | 10 | | | |

| SURNAME OF ACTION OFFICER AND GRADE | SYMBOL | PHONE | TYPIST'S INITIALS | SUSPENSE DATE |
|---|---|---|---|---|
| Major Owens Thanks. [illegible] | DOTA | DSN 579-5773 | jho | 26 May 00 |

| SUBJECT | DATE |
|---|---|
| AFSOC Cockpit Accommodation Series (CAS) Operational Requirements | 11 May 00 |

ACC Coordination Letter for A-10, F-15, F-16, F-117, B-1, B-2, B-52, H-60

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>
> MEMORANDUM FOR HQ AETC/XP
>
> FROM:     HQ ACC/DO
>     205 Dodd Boulevard, Suite 100
>     Langley AFB VA  23665-5000
>
> SUBJECT:  Aircraft Cockpit Accommodation Series (CAS) Study, ACC
> Operational
> Requirements
>
> 1.  ACC Functional Managers have reviewed the Air Force Research
> Laboratory
> (AFRL) proposed Body Size/Reach Requirements designed to define the
pilot
> body measurements required for aircraft operation.  Attached are the
> updated
> aircraft requirements based on flight manual required switch
actuations.
>
> 2.  We appreciate your efforts to determine pilot size limitations for
ACC
> aircraft.  Our efforts must ensure our pilots can employ their
aircraft
> effectively during training as well as combat.
>
>
> //signed//
> DONALD A. LAMONTAGNE
> Major General, USAF
> Director of Aerospace Operations
>
>
```

Author's Note: F-22 and T-6 requirements were based on Contract Requirements documents since both aircraft were in the procurement phase.